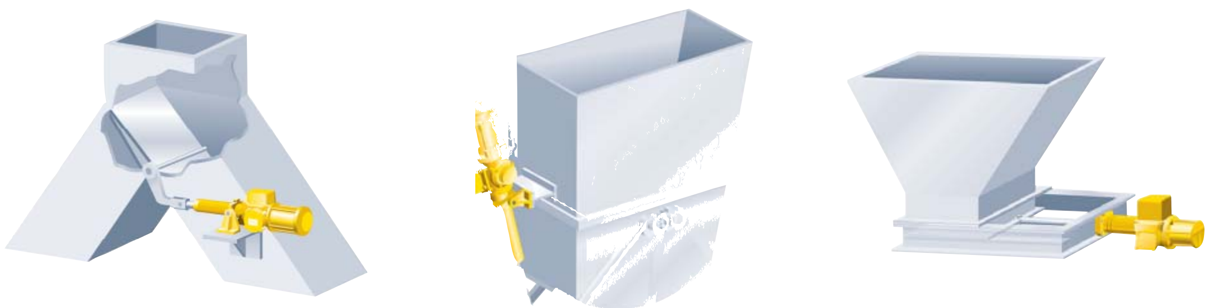
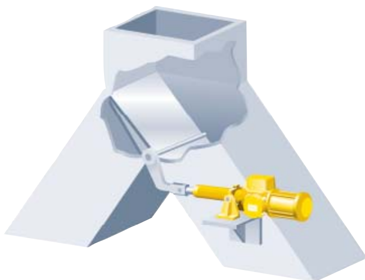
GE Oil & Gas

# Andco* Application Guide



www.avensys.com | info@avensys.com | 1-888-965-4700

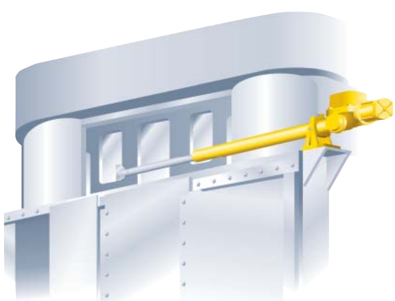
# Typical Applications



### Diverter Gate Valve
- Non-backdriving
- Thrust limit protection
- Accurate positioning

Clam Shell Gate
- High breakaway forces
- Positive closing
- Thrust overload protection

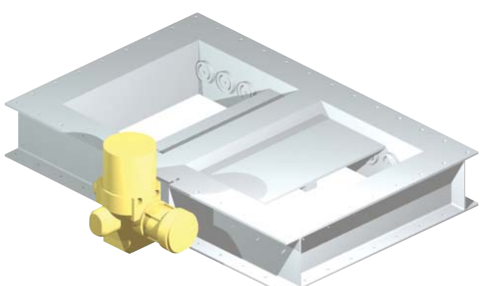
### Slide Gate
- Slow speeds for regulating flow
- High speeds for weighing and loadout
- Well suited for computer and programmable control



### Industrial Doors
- Long strokes
- Low maintenance
- Enclosures suitable for most environments

### Louver Damper
- Modulating control
- High seating forces
- Convenient mounting

### Antenna
- Accurate position feedback
- Slow speed
- Capable of high static loading



### Rack and Pinion Drive
- High starting torque
- Compact

# Application Guide

## Introduction

All Andco actuators are self-contained electro-mechanical machines with built in switches for control and protection. At high starting torque, low inertia electric motor is standard. The high starting torque is essential because more power is required to start an object in motion as opposed to keeping it in motion. Low inertia results in good positioning and stopping characteristics. All components are designed, constructed and tested with the intent of providing long and reliable service.

## How to Use this Application Guide

The Andco Actuator Application Guide will assist you in the proper application and selection of our actuators.

Several applications are illustrated with descriptions of operation, definitions of terminology, formulas to find required forces or torques and descriptive examples. Reference is made to the included data tables whenever this information is required.

To use this Guide, find the section that best typifies your application and follow the step-by-step methods and instructions that appear on the particular page.

If you should encounter any difficulty or have an application that does not appear in this Guide, please contact our Sales Office or Area Representative for assistance.

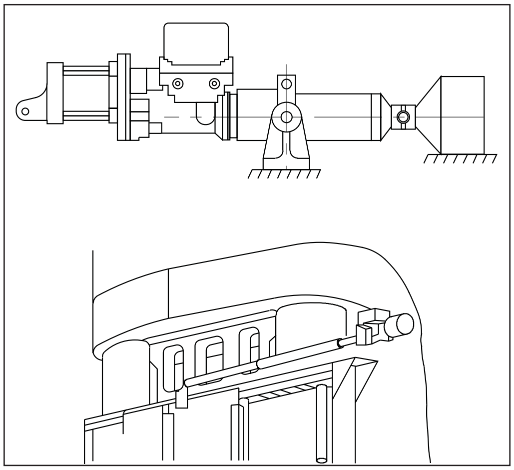
## Disclaimer

The information contained in this catalog is provided merely as a service to assist User in understanding Andco's products and their possible application to User's requirements. Andco, however, accepts no liability whatsoever with respect to the information, diagrams and formulas provided herein and EXPRESSLY DISCLAIMS ANY AND ALL EXPRESS OR IMPLIED WARRANTIES INCLUDING, BUT NOT LIMITED TO, IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. Please also note that Andco reserves the right to amend or delete the information at any time without being required to give notice to any other party

# General Applications

## Linear Applications

### Pushing and Pulling



| Legend | |
|---|---|
| $\mu 1$ & $\mu 3$ | coefficients of starting ($\mu 1$) and running friction ($\mu 3$)(Table 1) |
| W | weight of object being moved (lbs) |
| BAf | required breakaway force (lbs) |
| Rf | required running force (lbs) |
| a | acceleration factor (Table 3) |

Reference Tables on Page 12.

**Formulas**

BAf = W x $\mu 1$ x a = ______ lbs
Rf = W x $\mu 3$ = ______ lbs

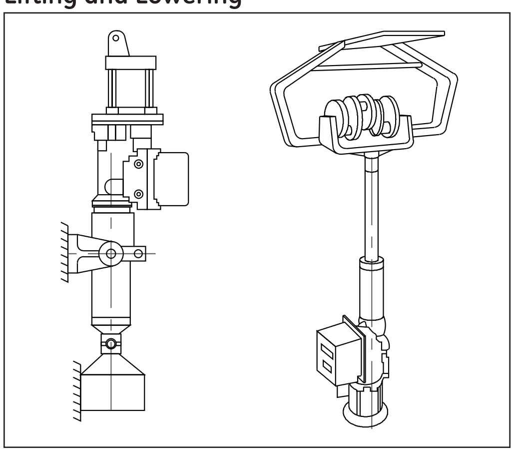
**Example**

Determine the force required to move a 1500 lb. safety door that is supported on ball bearings.

BAf = 1500 lbs x 0.08 x 1.2* = 144 lbs
Rf = 1500 lbs x 0.05 = 75 lbs

* Acceleration factor based on velocity of 3.5 in/sec or less.

### Lifting and Lowering



| Legend | |
|---|---|
| W | weight of object being moved (lbs) |
| BAf | required breakaway force (lbs) |
| Rf | required running force (lbs) |
| a | acceleration factor (Table 3) |

Reference Tables on Page 12.

**Formulas**

BAf = W x $\mu 1$ x a = ______ lbs
Rf = W x $\mu 3$ = ______ lbs

$$\text{Duty cycle} = \frac{\text{Running time (sec)/hour}}{\text{3600 sec/hour}} \times 100\% = \_\_\_\_\_\_\_\_ \%$$

**APPLICATION NOTE**

1. For lifting or constant load applications select the actuator according to running load requirements.

**Example**

A linear actuator is to lift a carriage (75 lbs) that supports a crankshaft (50 lbs). The linear velocity should be 10 in/sec with an actuator stroke length of 36 inches. Determine the actuator forces and duty at a rate of 250 crankshafts per hour.

BAf = 125 lbs. x 1.4 = 175 lbs     Rf = 125 lbs.

Running time = 36 inch stroke ÷ 10 inch/sec = 3.6 sec/stroke x 2 strokes/cycle = 7.2 sec/cycle

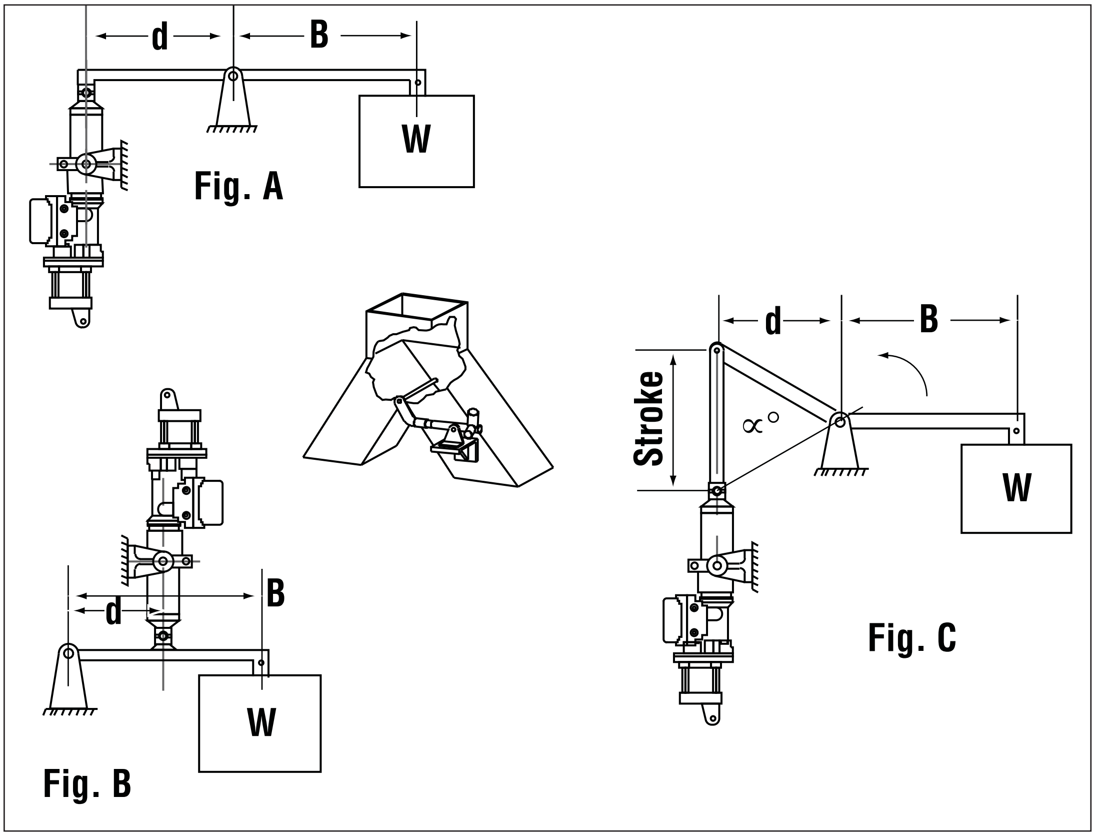
7.2 sec/cycle x 250 cycles/hour = 1800 sec/hour

Duty cycle = (1800 sec/hour ÷ 3600 sec/hour) x 100% = 50% duty

# General Applications

## Linear Applications

### Pushing and Pulling




| Legend | |
|---|---|
| W | weight of object being moved (lbs) |
| B | distance from pivot point to center of weight of the object being moved (ft) |
| d | effective lever arm length (Table 4) |
| BAf | required breakaway force (lbs) |
| Rf | required running force (lbs) |
| a | acceleration factor (Table 3) |

Reference Tables on Page 12.

**Formulas**

$$BAf = \frac{B \times W \times a}{d\ (ft)} = \_\_\_\_\_\_\_\_\_\_ \text{ lbs}$$

$$Rf = \frac{B \times W}{d\ (ft)} = \_\_\_\_\_\_\_\_\_\_ \text{ lbs}$$

**APPLICATION NOTE**

1. For lifting or constant load applications select the actuator according to running load requirements.

**Example**

From Fig C: If the actuator stoke is 6 inches, B = 4 ft, W = 800 lbs and∝° = 30°. Determine the necessary actuator forces.

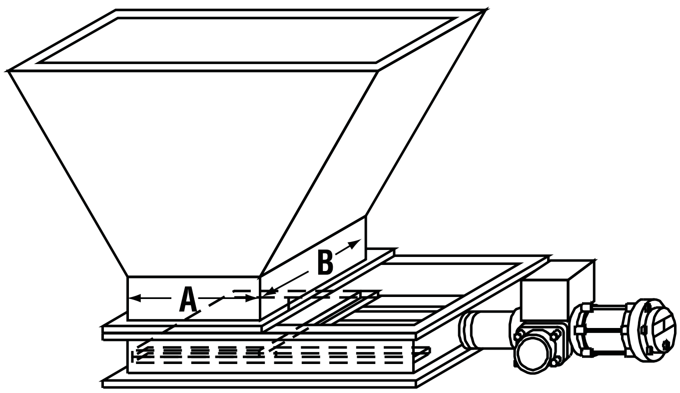
$$BAf = \frac{4\text{ ft} \times 800\text{ lbs} \times 1.2^*}{0.93\text{ ft (Table 4)}} = 4129\text{ lbs}$$

$$Rf = \frac{4\text{ ft} \times 800\text{ lbs}}{0.93\text{ ft (Table 4)}} = 3440\text{ lbs}$$

*Acceleration factor based on velocity of 3.5 in/sec or less.

# General Applications

## Slide Gates




**Gate Operation:** The maximum force required to operate a slide gate occurs when opening from a fully closed position with material resting on the gate blade. To move the gate, static friction must be overcome ($\mu 1$ and $\mu 2$). Once moving, the material weight on the gate is reduced, the friction is lower and the required force is reduced proportionally as the gate opens.

**Required Information:** Dimensions A and B, material being handled, effective height of material on the gate blade "H1", type of gate guide (steel plate, rollers, etc.)

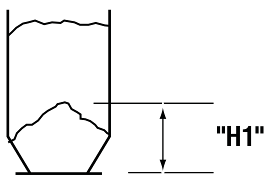



**Fig. 1**
**(fully loaded hopper)**

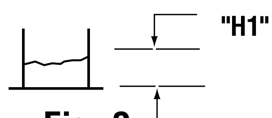



**Fig. 2**
**(gate under a conveyor)**

| Formulas |
|---|
| H1 = Larger of A or B dimensions x "h" factor from Table 2 = ______ft |
| W2 = A x B x H1 x W1 (material in the hopper) = ________lbs |
| W3 = A x B x GT x 490 (steel) = ________lbs |
| BAf = [W2 x $\mu$42 + (W2 + W3) x $\mu$2] x a = ____________lbs |
| Rf (avg) = $\dfrac{(W2 \times \mu 4) + [(W2 + W3) \times \mu 3)]}{1.75}$ = __________lbs |

| Example |
|---|
| Find the force required to operate a 3 foot square slide gate underneath a fully loaded 50 ft high storage hopper of grain. The gate blade is made of 1 inch thick steel supported on steel rollers. |
| W2 = 3 ft x 3 ft (3 ft x 4.75) x 40 lbs/ft$^3$ = 5130 lbs |
| W3 = 3 ft x 3 ft x (1 in/12 ins/ft) x 490 lbs/ft = 368 lbs |
| BAf = [(5130 lbs x 0.32) + ((5130 lbs + 368 lbs) x 0.15)] x 1.2* = 2960 lbs |
| Rf (avg) = $\dfrac{(5130 \text{ lbs} \times 0.2) + [(5130 \text{ lbs} + 368 \text{ lbs}) \times 0.10]}{1.75}$ = 900 lbs |

* Acceleration factor based on velocity of 3.5 in/sec or less.

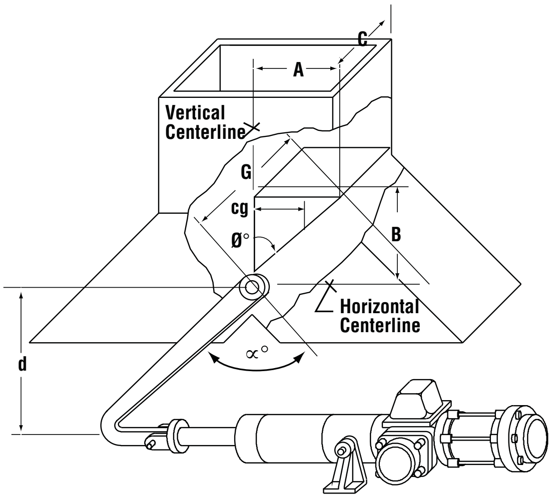
| Legend | |
|---|---|
| A | length of gate opening (ft) (also actuator travel) |
| B | width of gate opening (ft) |
| H1 | effective height of material on the gate blade (ft). See Figure 1 and 2 |
| W1 | average material specific weight (lbs/ft) (Table 2) |
| W2 | material weight on gate blade (lbs) (Table 2) |
| W3 | gate weight (lbs) (Table 2) |
| a | acceleration factor (Table 3) |
| $\mu$2 & $\mu$4 | coefficients of starting ($\mu$2) and running ($\mu$4) friction between the material in the hopper and gate blade (Table 2) |
| $\mu$1 & $\mu$3 | coefficients of starting ($\mu$1) and running ($\mu$3) friction between the gate blade and the gate guides. (Table 1) |
| BAf | required breakaway force (lbs) |
| Rf (avg) | average required running force (lbs) |
| Fig 1 | Material in a hopper will start to bridge or support itself a certain height (H1) above the gate blade. To find H1 use the "h" factor from Table 2 and the formula referenced. |
| Fig 2 | If the actual material above the gate blade is less than the calculated value of "H1" use the actual height in feet. |
| GT | Gate Thickness (ft) |

Reference Tables on Page 12.

| APPLICATION NOTE |
|---|
| 1. Select actuator according to breakaway force requirements. |
| 2. For rack and pinion slide gates use above forces. |

# General Applications

## Diverter Gates




**Gate Operation:**

- A diverter gate will produce a torque at the gate shaft directed away form the vertical centerline.

Torque (ft-lbs) (gate) = total weight (lbs) (W2 + W3) x distance (ft) (A/2)

- To move the gate back toward the centerline a torque must be produced by the actuator through a lever arm that will exceed the gate torque.

Torque (ft-lbs) (operating) = actuator force (lbs) x effective lever arm (ft) (d)

**Required Information:**

Dimensions C, G and angular travel Ø°. Dimensions A and B must be found.

A = G x (SIN Ø°) = _______ ft    B = G x (COS Ø°) = _______ ft

| Legend | |
|---|---|
| A | projected length of gate opening (ft) (measured from vertical centerline) |
| B | projected height of gate (ft) (measured from horizontal centerline) |
| C | width of gate (ft) |
| cg | assumed center of gravity of the gate (ft) |
| d | effective lever arm length (ft) (Table 4) |
| G | length of gate (ft) |
| Ø° | maximum angular travel of the gate from the vertical center line (degrees) |
| α | total angular travel (degrees) |
| W1 | average material specific weight (lbs/ft³) (Table 2) |
| W2 | assummed material weight hitting the gate (lbs) (Not used if gate is moved when no material is flowing) |
| W3 | gate weight (lbs) |
| a | acceleration factor (Table 3) |
| Rf | required running force (lbs) |
| BAf | required breakaway force (lbs) |
| T | total gate plate thickness (F1) (2 plates often used) |

Reference Tables on Page 12.

| Ø° | 15° | 30° | 45° | 60° |
|---|---|---|---|---|
| SIN Ø° | 0.26 | 0.50 | 0.71 | 0.87 |
| COS Ø° | 0.97 | 0.87 | 0.71 | 0.50 |

**Formulas**

$cg = \frac{A}{2}$    $W2 = \frac{A \times B \times C}{2} \times W1 =$ ________lbs

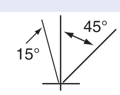
$W3 = C \times G \times T \times 490 =$ _____lbs

$Rf = \frac{[W2 \text{ (if applicable)} + W3] \times (cg)}{d \text{ (ft)}} =$ ______lbs

$BAf = Rf \times a =$ _________lbs

**APPLICATION NOTES**

1. Select actuator according to breakaway force requirements.
2. If the gate is non-symmetrical use the larger of the two angles for Ø°.




**Example**

Find the force required to move a 6 ft. long by 4 ft. wide diverter gate through a moving stream of coal.

The total angular travel is 60° (30° from the vertical centerline). The gate is fabricated from 2-3/8 inch steel plates. Due to space given requirements the actuator stroke should be 18 inch (max).

**Given:** C = 4 ft, G = 6 ft, Ø° = 30°, W1 = 55 lbs/ft³

**Calculations:** A = 6 ft x 0.5 = 3 ft, B = 6 ft x 0.87 = 5.22 ft

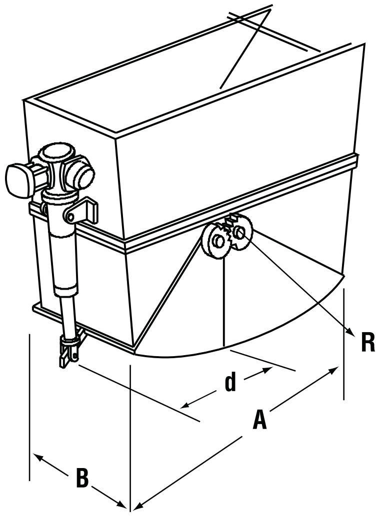
$W2 = \frac{3 \text{ ft} \times 5.22 \text{ ft} \times 4 \text{ ft}}{2} \times 55 \text{ lbs/ft}^3 = 1723 \text{ lbs}$    $W3 = (4 \text{ ft} \times 6 \text{ ft}) \times \left[\frac{0.375 \text{ (inch)} \times 2 \text{ plates}}{12 \text{ (in/ft)}}\right] \times 490 \text{ (lbs/ft}^3\text{)} = 735 \text{ lbs}$

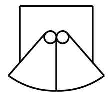
$Rf = \frac{(1723 \text{ lbs} + 735 \text{ lbs}) \times 1.5 \text{ ft}}{1.3 \text{ ft}} = 2836 \text{ lbs}$    BAf = 2836 lbs x 1.2* = 3403 lbs

* Acceleration factor based on velocity of 3.5 in/sec or less.

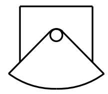
# General Applications

## Clam Shell or Undercut Gates

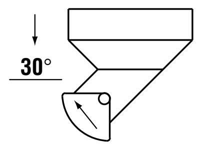


**Clamshell Gate**



**Undercut Gate**




**Undercut Gate with an Angled Chute**
**(Use "H1" x .87)**

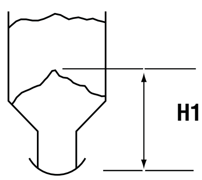



**Fig 1**
**(Fully Loaded Hopper)**

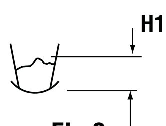



**Fig 2**
**(Partially Filled Gates)**

**Gate Operation:** The maximum force required to operate a clam shell and undercut gates occur when opening from a fully closed position when material is resting on the gate blade. To move the gate, static friction (μ2) must be overcome. Once moving, the material weight on the gate is reduced, the coefficient of friction is lower and the required force is reduced proportionally as the gate opens.

**Required Information:** Dimensions A, B, d* and R,* material being handled, gate weight (W3) and approximate material height above the gate blade "H1". *See legend if dimensions are not known.

| Legend | |
|---|---|
| A | length of gate opening (ft) (also actuator travel) |
| B | width of gate opening (ft) |
| d | effective length of lever arm (ft) (if specific dimension is known) use length of gate "A"/1.9 |
| H1 | effective height of material on the gate blade (ft). See Figure 1 and 2 |
| R | radius of gate (ft). If specific dimension is not known use (A/2 x 1.5) |
| W1 | average material specific weight (lbs/ft) (Table 2) |
| W2 | material weight on gate blade (lbs) (Table 2) |
| W3 | gate weight (lbs) (Table 2) |
| a | acceleration factor (Table 3) |
| μ2 & μ4 | coefficients of starting (μ2) and running (μ4) friction between the material in the hopper and gate blade (Table 2) |
| a | acceleration factor (Table 3) |
| BAf | required breakaway force (lbs) |
| Rf (avg) | average required running force (lbs) |
| Fig 1 | Material in a hopper will start to bridge or support itself a certain height (H1) above the gate blade. To find H1 use the "h" factor from Table 2 and the formula referenced. |
| Fig 2 | If the actual material above the gate blade is less than the calculated value of "H1" use the actual height in feet. |

Reference Tables on Page 12.

| Formulas |
|---|
| H1 = [Larger of A or B dimensions] x ["h" factor from Table 2] = ______ft |
| W2 = A x B x H1 x W1 = ________lbs |
| $BAf = \frac{[(W2 \times \mu2) + W3] \times R \times a}{d}$ = ________lbs |
| $Rf\,(avg) = \frac{[(W2 \times \mu4) + W3] \times R}{d \times 1.75}$ = _________lbs |

| Example |
|---|
| Determine the actuator force required to open a 4 ft. square coal refuse clam shell gate. The total weight of the gate is 750 lbs. No other dimensions are known. |
| W2 = 4ft x 4 ft (4 ft x 2.0) x 45 lbs/ft$^3$ = 5760 lbs |
| W3 = 750 lbs, R = (4 ft/2 x 1.5) = 3 ft, d = 4 ft/1.9 = 2.11 ft |
| $BAf = \frac{[(5760\text{ lbs} \times 0.75) + 750\text{ lbs}] \times 3\text{ ft} \times 1.2}{2.11\text{ ft}}$ = 8650 lbs |
| $Rf\,(avg) = \frac{[(5760\text{ lbs} \times 0.5) + 750\text{ lbs}] \times 3\text{ ft}}{2.11\text{ ft} \times 1.75\text{ ft}}$ = 2950 lbs |

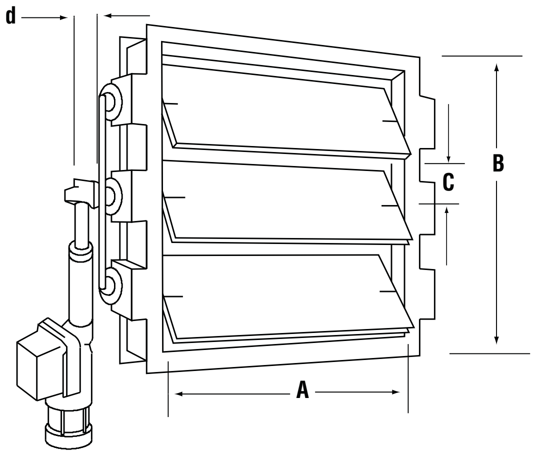
* Acceleration factor based on velocity of 3.5 in/sec or less.

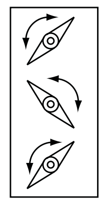
| APPLICATION NOTE |
|---|
| 1. Select actuator according to breakaway force requirements. |

Reference Tables on Page 12.

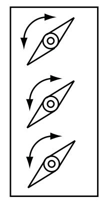
# General Applications

## Louver Damper



**Opposed Blade**



**Parallel Blade**

**Opposed blade louver dampers:** Typically used for gas or air flow control. Applications include baghouses, boilers, precipitators and scrubbers.

**Parallel blade louver dampers:** Used mainly for isolation or shut-off. Edges of adjacent blades usually overlap or contact seating bars or angles when damper is full closed.

**Required Information:** Damper size, blade size, number of blades.

| APPLICATION NOTES |
|---|
| 1. Effects of high gas temperatures are not included in above formulas |
| 2. For isolation or shut-off dampers select actuator according to breakaway torque or force requirements. |
| 3. For control damper select actuator according to running torque or force requirements. |

| Legend | |
|---|---|
| A | width of damper, or length of blade (in) |
| B | height of damper opening (in) |
| C | total half blade width (in) (see formula) |
| d | effective lever arm length (ft) (Table 4) |
| N | number of blades |
| R | contact pressure rate for blade to blade sealing (lbs/linear inch) |

Reference Tables on Page 12.

### Formulas

$$C = \frac{B\ (in)}{2 \times (N)} = \_\_\_\_\_\_ \text{ inches}$$

Shut off damper closure torque (in-lbs) = $[A \times C \times R \times (N+1)] + 2\,[C^2 \times R \times N] = \_\_\_\_\_\_$ in-lbs

$$\text{* Control damper operating torque (in-lbs)} = \frac{75\,[0.025 \times A \times B]^2}{(A \times N)} = \_\_\_\_\_\_ \text{ in-lbs}$$

* Operating torque is based on 3600 feet per minute gas velocity.

$$\text{Torque (ft-lbs)} = \frac{\text{torque (in-lbs)}}{12\ (in/ft)} = \_\_\_\_\_\_ \text{ ft-lbs} \qquad \text{Force (lbs)} = \frac{\text{torque (ft-lbs)}}{d} = \_\_\_\_\_\_ \text{lbs}$$

### Example

Determine the torque required to tightly close a parallel blade shut-off louver damper in a boiler flue gas duct 4 ft wide by 6 ft high. The damper has 4 blades and requires the closed blade edges to contact each other with a pressure of 4 lbs/in to obtain satisfactory gas shut off. Determine the force required if a 9 inch (.75 ft) effective lever arm length is used. Total damper rotation is 90°.

$$C = \frac{6\text{ ft} \times 12\text{ in/ft}}{(2 \times 4\text{ blades})} = 9 \text{ inches}$$

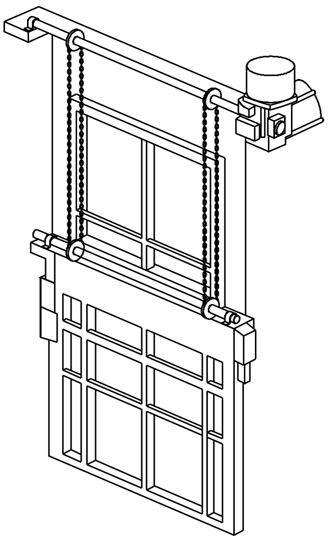
Shut off Damper closure torque (in/lbs) [ (4 ft x 12 (in/ft) ) x 9 in x 4 (lbs/in) x ( 4 blades + 1) ] + 2 [ 9 in x 4 (lbs/in) x 4 blades ] = 8928 in-lbs

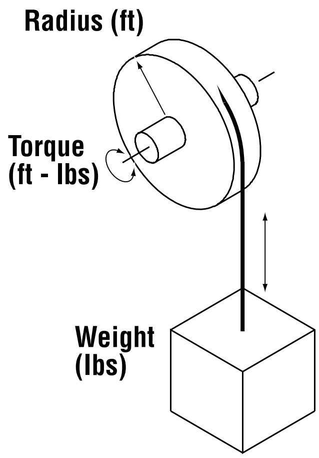
$$\text{Torque (ft/lbs)} = \frac{8928\text{ in/lbs}}{12/\text{in/ft}} = 744 \text{ ft/lbs;} \quad \text{Effective lever arm (ft)} = \frac{9\text{ in}}{12\text{ in/ft}} = 0.75\text{ ft}$$

$$\text{Force (lbs)} = \frac{744\text{ ft/lbs}}{0.75\text{ ft}} = 922\text{ lbs}$$

# Rotary Applications

## Pulleys and Sprockets






| APPLICATION NOTE |
| --- |
| 1. For lifting or constant load applications select the actuator according to running load requirements. |

Reference Tables on Page 12.

**Formulas**

$$\text{Radius} = \frac{\text{Diameter (in)}}{2} \quad \_\_\_\_\_\_\_\_\_\_\text{in;} \qquad \text{Radius} = \frac{\text{radius (in)}}{\text{12 (in/ft) d}} = \_\_\_\_\_\_\_\_\text{ft}$$

$$\text{Breakaway Torque} = \frac{\text{Radius of pulley or sprocket} \times \text{Weight} \times \text{(a) Acceleration factor (Table 3)}}{\text{belt/pulley or sprocket/chain efficiency}} = \_\_\_\_\_\_\_\text{ft-lbs}$$

$$\text{Running Torque} = \frac{\text{Radius of pulley or sprocket} \times \text{Weight}}{\text{belt/pulley or sprocket/chain efficiency}} = \_\_\_\_\_\_\_\text{ft-lbs}$$

$$\text{Actuator RPM} = \frac{\text{Velocity (in/sec)} \times \text{60 (sec/min)}}{\text{pitch dia (in)} \times 3.14} = \_\_\_\_\_\_\_\_\text{RPM}$$

**Example**

A rotary actuator is required to operate a 500 lb. vertical door through a chain and 6 inch diameter sprocket. The door travel is 65 inches and should close in approximately 10 seconds. What actuator torque and RPM is required? Assume an efficiency of 85% between the chain and sprocket.

$$\text{Radius of sprocket} = \frac{\text{6 (in) diameter}}{2} = \text{3 in}$$

$$\text{Radius of sprocket} = \frac{\text{3 (in) radius}}{\text{12 (in/ft)}} = \text{0.25 ft}$$

$$\text{Breakaway Torque} = \frac{\text{0.25 (ft)} \times \text{500 (lbs)} \times \text{1.4 (ft)}}{\text{0.85 efficiency}} = \text{206 ft/lbs}$$

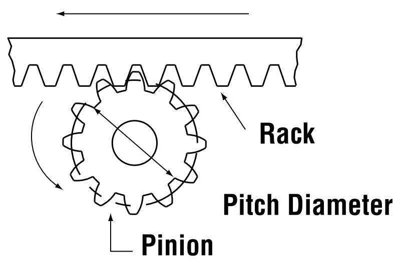
$$\text{Torque} = \frac{\text{0.25 (ft)} \times \text{500 lbs}}{\text{0.85 efficiency}} = \text{147 ft/lbs}$$

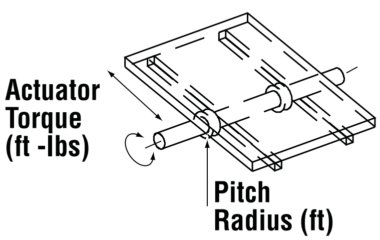
Linear Velocity = 6.5 (in) travel/10 seconds operating time = 6.5 in/sec

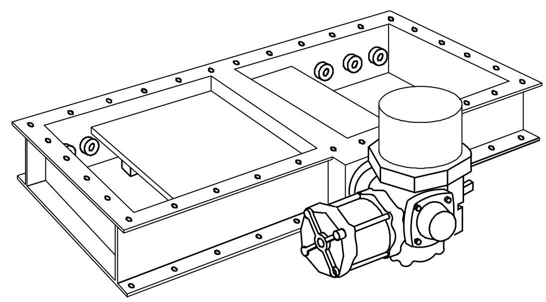
$$\text{Actuator RPM} = \frac{\text{6.5 (in/sec)} \times \text{60 (sec/min)}}{\text{6 (in) dia sprocket} \times 3.14} = \text{21 RPM}$$

# General Applications

## Rack and Pinion Gates



**Formulas**

$$\text{Pitch Diameter} = \frac{\text{Number of Teeth on Pinion}}{\text{Diameter Pitch}} = \underline{\qquad\quad}\text{in}$$

$$\text{Pitch Radius} = \frac{\text{Pitch Diameter (in)}}{2} = \underline{\qquad\quad}\text{in}$$

$$\text{Pitch Radius} = \frac{\text{Pitch Radius (in)}}{12\text{ (in/ft)}} = \underline{\qquad\quad}\text{ft}$$

$$\text{Actuator RPM} = \frac{\text{Velocity (in/sec)} \times 60\text{ (sec/min)}}{\text{pitch dia (in)} \times 3.14} = \underline{\qquad\quad}\text{RPM}$$

$$\text{Velocity} = \frac{\text{Actual RPM}}{60\text{ (sec/min)}} \times \text{Pitch diameter (in)} \times 3.14 = \underline{\qquad\quad}\text{in/sec}$$

$$\text{Number of Output Revolutions} = \frac{\text{Total Travel (in)}}{\text{Pitch diameter (in)} \times 3.14} = \underline{\qquad\quad}\text{revs}$$

$$\text{Actuator Torque} = \text{Force (lbs)} \times \left[\frac{\text{Pitch Radius (ft)}}{0.9}\right] = \underline{\qquad\quad}\text{ft/lbs}$$

(Assume efficiency between Rack and Pinion Gears)

**Example**

An 18 inch slide gate is found to require 1600 lbs. of breakaway force. Find the actuator torque and RPM required to obtain a minimum linear velocity o 2.5 ins/sec using a 2 inch pitch diameter pinion.

$$\text{Pitch Radius} = \frac{2\text{ (in) pitch diameter}}{2} = 1\text{ inch}$$

$$\text{Pitch Radius} = \frac{1\text{ (in) pitch radius}}{12\text{ (in/ft)}} = 0.083\text{ ft}$$

$$\text{Actuator Torque} = 1600\text{ (lbs)} \times \left[\frac{0.083\text{ (ft)}}{0.9\text{ efficiency}}\right] = 148\text{ ft/lbs}$$

$$\text{Actuator RPM} = \frac{2.5\text{ (in/sec)} \times 60\text{ (sec/min)}}{2\text{ (in) pitch diameter} \times 3.14} = 24\text{ RPM}$$

**APPLICATION NOTES**

For each rack and pinion slide gate find:

1. Force required to operate the gate

2. Pinion pitch diameter

Reference Tables on Page 12.

# Engineering Tables

Table 1

| Guide Type | Coefficient of Friction Between Steel Plate and Various Type Guides | | | |
|---|---|---|---|---|
| | Dry | | Lubricated | |
| | Starting (μ1) | Running (μ3) | Starting (μ1) | Running (μ3) |
| Ball Bearings | – | – | 0.08 | 0.05 |
| Steel Rollers | – | – | 0.15 | 0.10 |
| Bronze | 0.45 | 0.20 | 0.2 | 0.15 |
| Steel | 0.4 - 0.8 | 0.2 - 0.4 | 0.2 - 0.4 | 0.15 - 0.2 |

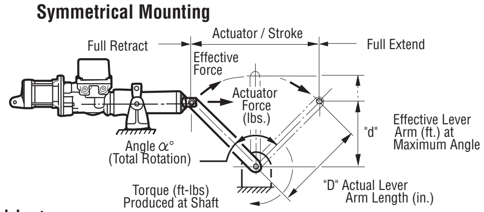
Table 2

| Material | Coefficient of Friction Between Steel Plate and Various Materials | | Specific Weights "W1" (lbs/ft³) | Column Height Factor "h" |
|---|---|---|---|---|
| | Starting (μ2) | Running (μ4) | | |
| Ash (fly) | 0.6-0.7 | 0.3 | 40-45 | 3.0 |
| Ash (wet) (coal refuse) | 0.75-0.95 | 0.5 | 45-50 | 2.0 |
| Cement (portland) | 0.6-0.65 | 0.3 | 95-100 | 3.0 |
| Cement (clinker) | 0.55-0.6 | 0.3 | 80-95 | 4.0 |
| Coal (anthracite) | 0.50-0.55 | 0.25 | 55-60 | 4.5 |
| Coal (bituminous) | 0.55-0.6 | 0.3 | 45-55 | 3.0 |
| Coke | 0.55-0.6 | 0.3 | 25-35 | 3.5 |
| Grain | 0.32-0.40 | 0.2 | 40-50 | 4.75 |
| Iron Ore | 0.55-0.65 | 0.3 | 125-180 | 3.5 |
| Limestone (crushed) | 0.55-0.65 | 0.3 | 80-90 | 3.5 |
| Rock (crushed) | 0.65-0.7 | 0.3 | 125-140 | 4.0 |
| Sand (dry) | 0.5-0.55 | 0.3 | 90-110 | 4.0 |
| Sand (damp) | 0.6-0.65 | 0.4 | 110-125 | 2.5 |
| Slag (blast furnace) | 0.4-0.45 | 0.2 | 80-90 | 5.5 |
| Steel | See Table 1 | See Table 1 | 490 | – |
| Taconite | 0.35-0.4 | 0.2 | 120-130 | 8.25 |
| Wood Chips | 0.75-0.8 | 0.4 | 10-30 | 2.5 |

Table 3

| | | | | |
|---|---|---|---|---|
| Velocity | 0.1-3.5 | 3.6-6..4 | 6.4-12.2 | 12.3-25.0 |
| Acceleration Factor (a) | 1.2 | 1.3 | 1.4 | 1.5 |

**Symmetrical Mounting**




**Non-Symmetrical Mounting**

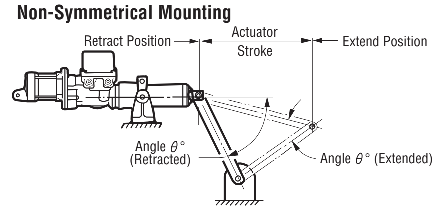



Table 4

| Angle a | 6" Stroke | | 12" Stroke | | 18" Stroke | | 24" Stroke | |
|---|---|---|---|---|---|---|---|---|
| | d' | D" | d' | D" | d' | D" | d' | D" |
| **30°** | .93 | 11.6 | 1.87 | 23.2 | 2.80 | 34.8 | 3.73 | 46.4 |
| **45°** | .60 | 7.8 | 1.21 | 15.7 | 1.81 | 23.5 | 2.41 | 31.4 |
| **60°** | .43 | 6.0 | .87 | 12.0 | 1.30 | 18.0 | 1.73 | 24.0 |
| **90°** | .25 | 4.2 | .50 | 8.5 | .75 | 12.7 | 1.00 | 17.0 |

| Angle a | 30" Stroke | | 36" Stroke | | 48" Stroke | | 60" Stroke | |
|---|---|---|---|---|---|---|---|---|
| | d' | D" | d' | D" | d' | D" | d' | D" |
| **30°** | 4.67 | 58.0 | 5.60 | 69.5 | 7.46 | 92.7 | 9.33 | 115.9 |
| **45°** | 3.02 | 39.2 | 3.62 | 47.0 | 4.83 | 62.7 | 6.04 | 78.4 |
| **60°** | 2.17 | 30.0 | 2.60 | 36.0 | 3.46 | 48.0 | 4.33 | 60.0 |
| **90°** | 1.25 | 21.2 | 1.50 | 25.5 | 2.00 | 33.9 | 2.50 | 42.4 |

| Angle Ø° | 5° | 15° | 30° | 45° | 60° | 75° | 90° |
|---|---|---|---|---|---|---|---|
| **Force Factor** | 0.09 | 0.26 | 0.50 | 0.71 | 0.87 | 0.97 | 1.00 |

Effective force (lbs) = Actuator force (lbs) x force factor
Effective lever arm (ft) = Actual length arm (ft) x force factor

**NOTES**

1. For non-symmetrical mounting the angle Ø° will change as the actuator moves through its travel. The angle Ø° is formed between the actuator drive rod centerline and the lever arm axis.

Torque (ft-lbs) = Effective lever arm (ft) x actuator force (lbs)
Force Required (lbs) = Torque (ft-lbs) ÷ Effective lever arm (ft)

# Application Notes

1. **Operation at 50 Cycle** – When an actuator is operated at 50 HZ, the velocity or output RPM will be 1/6th less than at 60 HZ, whereas the torque or force ratings remain the same. (60 HZ speed x 0.83 = ________ 50 HZ speed). Class F motor insulation should be used. Always specify if an actuator is going to be run at 50 cycle.
2. **Motor Insulation** – Class B insulation is supplied as standard. Class F motor insulation should be used for ambient temperatures above 40°C. (approx. 100°F) and for installations in high altitudes (3300 ft. and above).
3. **Temperature Limits** –Actuators can be supplied for the temperature ranges specified. For ambient temperatures outside the given ranges please consult factory.
4. **Simultaneous Control of Multiple Actuators** – Actuators can be run simultaneously if operated from a common control.

### Hydraulic and Pneumatic Cylinder Forces

Force (extend) = Pressure (psi) x Area of Bore Dia. ($in^2$) = ________lbs.

Force (retract) = Pressure (psi) x Area of Bore Dia. ($in^2$) - Area of Rod Dia. ($in^2$) = ________lbs.

$$\text{Cylinder Velocity} = \frac{231 \times \text{Flow Rate (GPM)}}{60 \times \text{Area (in}^2)} = \_\_\_\_\_\_\_\_\_\_\_\_ \text{ (in/sec)}$$

### Other Formulas and Conversions

Area of Circle = $\pi R^2$ = ___________($in^2$), $\pi$ = 3.14, R = Radius (in)

Circumference of a Circle = $\pi$ D, $\pi$ = 3.14, D = Diameter (in)

$$\text{Torque} = \frac{\text{H.P.} \times 5250}{\text{RPM}} = \_\_\_\_\_\_\_\_\_ \text{ft.-lbs}$$

Inches of Water (Water Column) x 0.03613 = ___________psi

Feet of Water x 0.4335 = __________psi

Inches of Mercury x 0.4912 = ___________psi

Millimeters/25.4 = __________inches

Kilogram x 2.21 = __________lbs (force)

$$T_C = \frac{5}{9} \times (T_f - 32)$$

$$T_f = \frac{9}{5} \times (T_C + 32)$$

# Definitions of Terms

**Acceleration Factor** – Acceleration is rate of velocity change with respect to time. Actuator acceleration occurs from the time an object is initially placed in motion until full speed (velocity) is obtained. A recommended Acceleration Factor is given in Table 3. (Higher velocity → higher acceleration factor)

**Acme Screw Drive** – Type of actuator drive that has a rotating drive screw with a mating drive nut that moves axially along the length of the screw. Sliding contact exists between the nut and screw. Andco Actuators are designed to have optimum efficiency while still having self-locking features in the back drive mode.

**Ball Screw Drive** – An actuator drive screw and nut with matching helical grooves running between them. Captured within the grooves are recirculating ball bearings. The efficiency is very high, allowing actuators to run at high duties and high velocities.

**Breakaway Force** – The starting or initial force required to produce motion. An Andco Actuator can develop its full breakaway thrust at any point in travel, however it should only be applied as a momentary force.

**Breakaway Torque** – Same context as above except torque implies rotation.

**Center of Gravity** – The point of an object about which it will balance. In this manual, the center of gravity is sometimes referred to as the center of weight.

**Closed Loop Control** – Automatic measuring of a process medium (temperature, pressure, current, etc.) for the purpose of controlling a valve, damper, etc. to maintain a desired process level. Typically a process signal (4-20 mAdc, etc.) is supplied to Andco Controller that will signal the final control element (Andco Actuator) to move an appropriate amount for positioning a valve, damper, etc.

**Coefficient of Running Friction** - A factor of resistance to movement between two contacting surfaces that have motion between them. (See Tables 1 and 2).

**Coefficient of Starting Friction** – A factor of resistance to movement between two contacting surfaces at rest. (See Tables 1 and 2).

**Differential Pressure** ($\Delta$ p) – The difference in pressure between two locations within a system. A common unit of measurement is pounds per square inch (psi).

**Duty Cycle** – Actual operating time of actuator as compared to off time during a one hour time period.

$$\text{Duty cycle} = \frac{\text{Actual Running Time (sec)}}{\text{3600 Seconds/Hour}} \times 100 = \_\_\_\_\_\_\%$$

**Hammerblow** – An actuator feature that permits the motor to attain full speed before the actuator output drive sleeve begins to move the load. This feature serves as an impact type device which aides in starting an object in motion. The hammerblow effect will be encountered every time the actuator is reversed (QR &QRG Series Actuators are supplied with the hammerblow feature as standard). This is sometimes referred to as a LOST MOTION DEVICE. (See No Lost Motion).

**Hazardous Location** – An area containing explosive or flammable vapor, gas fibers or dust in sufficient quantity to cause an explosion or fire. (Specify class, division and group).

| | | |
|---|---|---|
| | Class I | Flammable vapors and gases. |
| | Class II | Combustible dust. |
| | Division I | Hazard is present under normal conditions. |
| | Division II | Hazard is present under abnormal conditions. |
| **Class I** | Group A | Atmospheres containing acetylene. |
| | Group B | Atmospheres containing hydrogen and others. |
| | Group C | Atmospheres containing carbon monoxide, ethylene, hydrogen sulfide and others. |
| | Group D | Atmospheres containing gasoline, hexane, naphtha, benzine, butane, proposane acetone, benzol, alcohol, lacquer solvent vapors, natural gas and others. |
| **Class II** | Group E | Atmospheres containing metal dust. |
| | Group F | Atmospheres containing carbon black, coke or coal dust. |
| | Group G | Atmospheres containing grain, starch, or flour dust. |

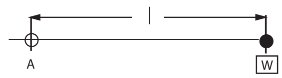
# Definitions of Terms

**Modulating Service:**

**Continuous Modulating Actuator Service** – Frequent or at times continuous incremental movement. Actuators that are part of closed loop process control should be rated for continuous modulating service

**Intermittent Modulating Actuator Service** – Frequent incremental movement for limited periods of time. The controlled mechanism is not subject to constant regulation (i.e. mixing or blending of materials).

**Moment Arm** – Perpendicular distance (l) from the center of gravity to the pivot point (A).




**Motor Brake** – An electro-mechanical device that will prevent motor rotation when the actuator is de-energized. Brakes are used on actuators to hold position under load. (i.e. ball screw drives, acme screw drives that are subject to high vibration causing the motor shaft to rotate and the actuator to creep.)

**Motor Starter** – A device that controls and protects a motor. The individual components that normally are supplied with a starter are described below:

**Contractor** – The main power contacts of the starter. For a three phase reversing motor three contacts are used for each direction of rotation. The main contacts carry the three phase (primary) voltage supply. The primary contacts are opened and closed by means of auxiliary contacts that are activated from a 115 Volt (nominal coil).

**Control Circuit** – The low voltage (secondary) circuit that contains any push button, selector or actuator limit switches that will activate or deactivate the 115 Volt coil to open or close the main contacts of the starter. Also contained in the control circuit are secondary fuses and a mechanical interlock.

**Control Transformer** – Connected across any two of the high voltage (primary) power leads. The transformer reduces the high voltage to a 115 VAC (nominal) control voltage (secondary) which acts as a control circuit voltage supply.

**Mechanical Interlock** – Prevents opposite rotation main power contacts from being energized at the same time (i.e., if the extend and retract push buttons were pushed at the same time only one direction would energize.)

**Overload Relay** – Connected between the main power contacts and the actuator motor. The relay will open the circuit if excessive current is present for a certain period of time.

**No Lost Motion Drive** – For applications that require frequent reversals or incremental movement (i.e., modulating control) the output drive should engage with a minimum amount of free play upon reversal. (Specify No Lost Motion) (See Hammerblow.)

**On-Off Duty (Control)** – Actuator will move to either full extend or full retract, full open or full close positions. The actual actuator running time should be less than 5%.

**Pressure Drop** – Another term for differential pressure. (See Differential Pressure.)

**Specific Weight** – Weight per unit volume of a particular material (lbs/ft$^3$). (See Table 2).

**Torque** – The product of force and perpendicular distance from a pivot point. Torque will tend to produce rotation about the pivot point.

# Andco Ordering Information

**When ordering or requesting a quotation please specify the following:**

1. Desired breakaway and running force (pounds)
2. Desired velocity (inches/second)
3. Desired stroke (inches)
4. Desired duty
5. Ambient temperature if below -30° F or above 120°F
6. Power and control voltage and other relevant electrical specifications:
   a. Motor voltage, frequency and phase
   b. Motor insulation
   c. Motor brake
   d. Motor space heater
7. Enclosure (weatherproof or dust-ignition proof)
8. Desired mounting (clevis, trunnion or face/flange)
9. Desired options:
   a. Additional position limit switches or contacts
   b. Potentiometer(s) or encoder
   c. Limit switch compartment heater
   d. Motor heater
   e. Handwheel
   f. Rod cover
   g. Single or Three Phase Motor Control
   h. Motor brake
10. Internal Controls:
    a. Positran Transmitter
    b. Electric Actuator Smart Control (EASC)
    c. Profibus® DP
    d. DeviceNet™
    e. ModBus®
11. Separately mounted options
    a. 4100 Position Indicator
    b. 5100 Remote Position/Process Control