

# Selection Guide (Push Force / Continuous Operation Thrust)

## RCS2 Series Rod Ultra-high thrust type

The following three conditions must be met when using this device.

- Condition 1:** The pushing time must be **less than the time determined**.
- Condition 2:** One cycle of **continuous thrust** must be less than the rated thrust for an ultra-high thrust actuator.
- Condition 3:** There must be **one pushing operation** in one cycle.

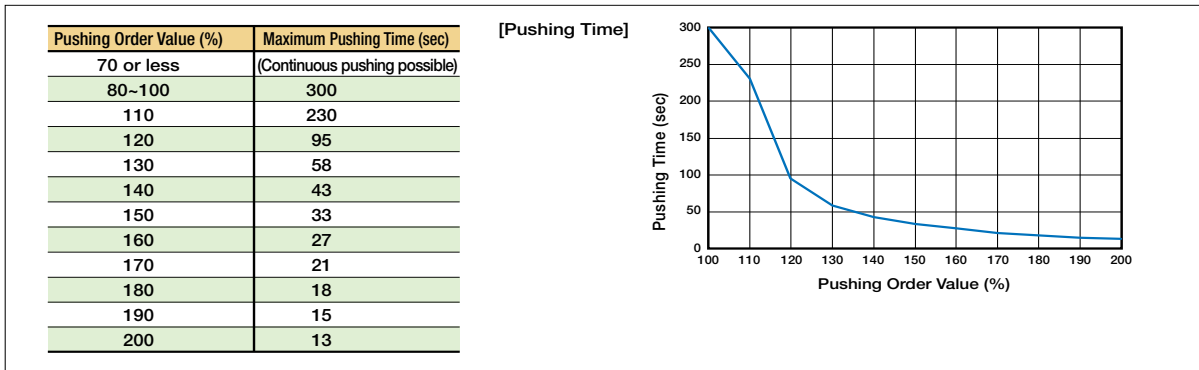
### Selection Method

#### Condition 1. Pushing Time

The maximum pressing time for each pressing order must be determined as shown in the table below. The pressing time used must be less than the time indicated in the table below.

Actuator malfunction could result if the process is used without adhering to the table below.

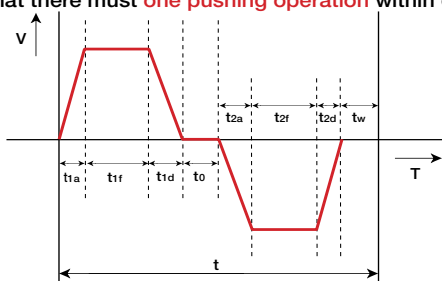
Table 1



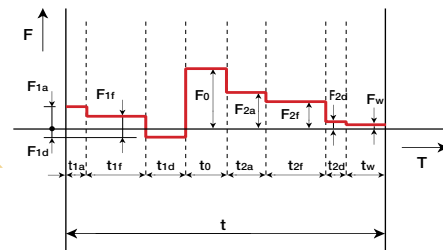
#### Condition 2. Continuous Operation Thrust

Confirm that 1 cycle of continuous operation thrust Ft, based on a consideration of load and duty, is less than that of the rated thrust for a ultra-high-thrust actuator.

Note that there must be **one pushing operation** within one cycle.



Re-plot this using the thrust values as the vertical axis



- t : Operation duration per cycle (s)
- t<sub>1a</sub> : Acceleration duration1
- t<sub>1f</sub> : Constant speed duration1
- t<sub>1d</sub> : Deceleration duration1
- t<sub>0</sub> : Pushing duration
- t<sub>2a</sub> : Acceleration duration2
- t<sub>2f</sub> : Constant speed duration2
- t<sub>2d</sub> : Deceleration duration2
- t<sub>w</sub> : Waiting duration

- F<sub>1a</sub> : Thrust1 needed for acceleration
- F<sub>1f</sub> : Thrust1 needed for motion at constant speed
- F<sub>1d</sub> : Thrust1 needed for deceleration
- F<sub>0</sub> : Thrust needed for pushing
- F<sub>2a</sub> : Thrust2 needed for acceleration
- F<sub>2f</sub> : Thrust2 needed for motion at constant speed
- F<sub>2d</sub> : Thrust2 needed for deceleration
- F<sub>w</sub> : Thrust needed for waiting

Use the equation below to calculate the continuous operation thrust Ft for one cycle.

$$F_t = \sqrt{\frac{F_{1a}^2 \times t_{1a} + F_{1f}^2 \times t_{1f} + F_{1d}^2 \times t_{1d} + F_0^2 \times t_0 + F_{2a}^2 \times t_{2a} + F_{2f}^2 \times t_{2f} + F_{2d}^2 \times t_{2d} + F_w^2 \times t_w}{t}}$$

\* For horizontal use, it is not necessary to calculate the thrust needed for constant speed motion and for waiting.

● Since F<sub>1a</sub>/F<sub>2a</sub>/F<sub>1d</sub>/F<sub>2d</sub> will change with the direction of motion, use the equations below.

- Horizontal use (for both accel./decel.) F<sub>1a</sub> = F<sub>1d</sub> = F<sub>2a</sub> = F<sub>2d</sub> = (M+m) × d
- Vertical use, downward acceleration F<sub>1a</sub> = (M+m) × 9.8 - (M+m) × d
- Vertical use, constant downward speed F<sub>1f</sub> = (M+m) × 9.8 + α(\*1)
- Vertical use, downward deceleration F<sub>1d</sub> = (M+m) × 9.8 + (M+m) × d
- Vertical use, upward acceleration F<sub>2a</sub> = (M+m) × 9.8 + (M+m) × d
- Vertical use, constant upward motion F<sub>2f</sub> = (M+m) × 9.8 + α(\*1)
- Vertical use, upward deceleration F<sub>2d</sub> = (M+m) × 9.8 - (M+m) × d
- Vertical use, waiting F<sub>w</sub> = (M+m) × 9.8

- M : Moveable weight (kg)
- m : Loaded weight (kg)
- d : Accel./decel. (m/s<sup>2</sup>)
- α : Thrust (taking into account the travel resistance by the external guide.)

Moveable weight for ultra-high thrust actuator: 9kg

\*1 If an external guide is attached, it is necessary to consider travel resistance.

- The method of calculating  $t_a$ , which is the acceleration duration, will vary for ① trapezoidal pattern vs. ② triangular pattern movements. Whether a movement pattern is trapezoidal or triangular can be determined by whether the peak speed reached after accelerating over a distance at a specified rate is greater than or less than the specified speed.

Peak Speed (Vmax) =  $\sqrt{\text{Distance Moved (m)} \times \text{Set Acceleration (m/s}^2\text{)}}$

Set Speed < Peak Speed → ① Trapezoidal Pattern

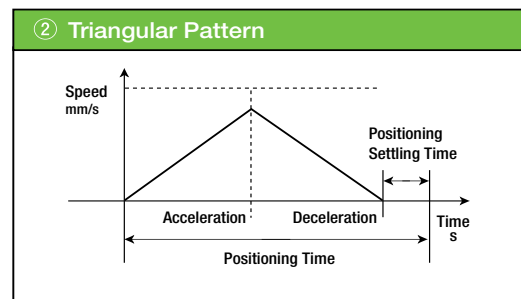
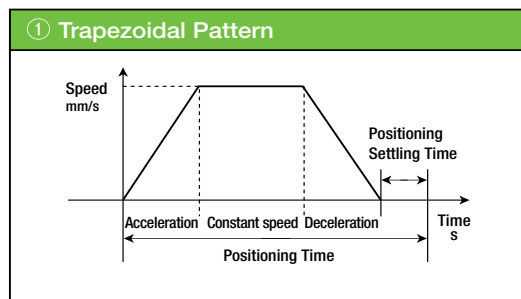
Set Speed > Peak Speed → ② Triangular Pattern

① For trapezoidal pattern,

$t_a = V_s/a$   $V_s$  : Set speed (m/s)  $a$  : Ordered acceleration (m/s<sup>2</sup>)

② For triangular pattern

$t_a = V_t/a$   $V_t$  : Peak speed (m/s)  $a$  : Ordered acceleration (m/s<sup>2</sup>)



- $t_f$  is the time taken to move at constant speed. You can calculate this time by computing the distance moved at constant speed.  $t_f = L_c/V$   $L_c$  : Distance moved at constant speed (m)  $V$  : Commanded acceleration (m/s)

\* Distance moved at constant speed = total distance – accelerated distance – decelerated distance    Accel./decel. distance =  $V^2/2a$

- $t_d$  is the deceleration time. This is the same as the acceleration time, if the magnitude of acceleration and deceleration are the same.  $t_d = V/a$   $V$  : Set speed (trapezoidal pattern) or Peak speed (triangular pattern)(m/s)  $a$  : Commanded deceleration (m/s<sup>2</sup>)

If the continuous operation thrust  $F_t$  by this method is less than the rated thrust, then operation is possible.

**Rated thrust for ultra-high thrust actuator with 2.5 lead: 5100N**

**Rated thrust for ultra-high thrust actuator with 1.25 lead: 10200N**

Operation is possible if both of the above operating conditions 1 and 2 are met.

If either condition cannot be met, make adjustments such as shortening the pushing operation time or decreasing the duty.

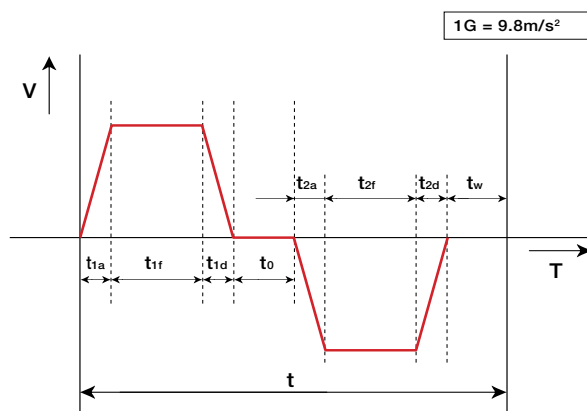
### Sample Problem

- Select an operation pattern by using the selection method described above.

#### Operating Conditions

- Model used : Ultra-high thrust actuator with 1.25 lead
- Mounting orientation : Vertical
- Speed : 62mm/s
- Acceleration : 0.098m/s<sup>2</sup> (0.01G, same value for deceleration.)
- Distance moved : 50mm
- Payload : 100kg
- Push order value : 200% (2000kgf)
- Pushing Time : 3 seconds
- Wait time : 2 seconds
- Push down 50mm, then raise 50mm, and finally wait 2 seconds. The conditions for downward and upward motions are identical.

Plotting the above operation yields the graph on the right.



# Selection Guide (Push Force / Continuous Operation Thrust)

Using the selection method:

**Condition 1. Confirm push operation time**

By comparing our push time of 3 seconds with the maximum push time for a push order value of 200%, which is 13 seconds (see Table 1 on page A-71), **it is clear that the pressing time is acceptable.**

**Condition 2. Calculate the continuous operation thrust**

Substitute the above operational pattern to the previously mentioned equation for continuous operation thrust.

$$F_t = \sqrt{\frac{F_{1a}^2 \times t_{1a} + F_{1f}^2 \times t_{1f} + F_{1d}^2 \times t_{1d} + F_0^2 \times t_0 + F_{2a}^2 \times t_{2a} + F_{2f}^2 \times t_{2f} + F_{2d}^2 \times t_{2d} + F_w^2 \times t_w}{t}}$$

At this point, by looking at the motion pattern for t1a/t1d/t2a/t2d, the peak speed (Vmax) =  $\sqrt{0.05 \times 0.098} \rightarrow 0.07\text{m/s}$ , which is greater than the set speed, 62mm/s (0.06m/s). Hence this is a trapezoidal pattern.

Hence,  $t_{1a}/t_{1d}/t_{2a}/t_{2d} = 0.062 \div 0.098 \rightarrow 0.63\text{s}$

Next, calculate t1f/t2f:

Distance moved at constant speed =  $0.05 - \{(0.062 \times 0.062) \div (2 \times 0.098)\} \times 2 \rightarrow 0.011\text{m}$ , so  $t_{1f}/t_{2f} = 0.011 \div 0.062 \rightarrow 0.17\text{s}$ .

Also, calculating the F1a/F1f/F1d/F2a/F2f/F2d from the equations yields the following:

$$F_{1a} = F_{2d} = (9+100) \times 9.8 - (9+100) \times 0.098 \rightarrow 1058\text{N}$$

$$F_{1d} = F_{2a} = (9+100) \times 9.8 + (9+100) \times 0.098 \rightarrow 1079\text{N}$$

$$F_{1f} = F_{2f} = f_w = (9+100) \times 9.8 \rightarrow 1068\text{N}$$

By substituting these values to the continuous operation thrust equation,

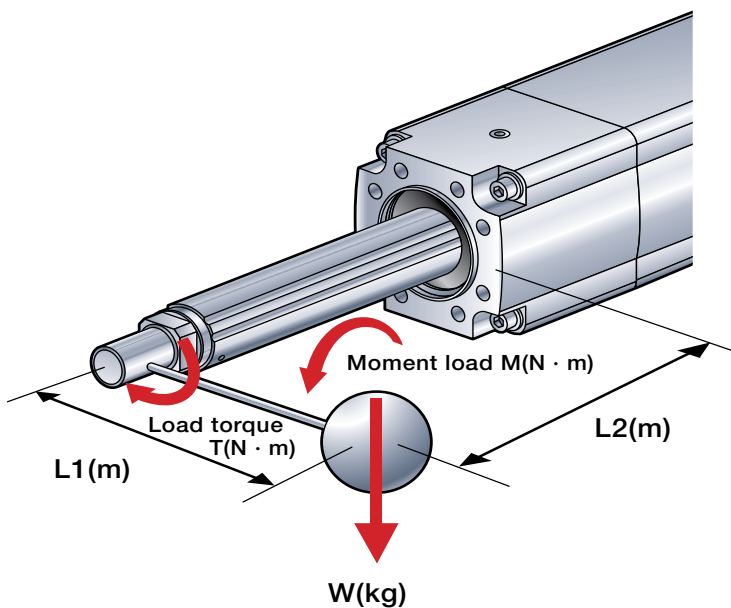
$$F_t = \sqrt{\frac{\{(1058 \times 1058) \times 0.63 + (1068 \times 1068) \times 0.17 + (1079 \times 1079) \times 0.63 + (19600 \times 19600) \times 3 + (1079 \times 1079) \times 0.63 + (1068 \times 1068) \times 0.17 + (1058 \times 1058) \times 0.63 + (1068 \times 1068) \times 2\}}{0.63 + 0.17 + 0.63 + 3 + 0.63 + 0.17 + 0.63 + 2}} \rightarrow 12113\text{N}$$

Since this exceeds the rated thrust for the 2-ton ultra-thrust actuator, which is 10200N, **operation with this pattern is not possible.**

In response, let us increase the wait time. (i.e. decrease the duty)

Recalculating with tw=6.12s(t=12s) will change the thrust to Ft=9814N, **making it operable.**

## Information on Moment Selection



The ultra-high thrust actuator can apply a load on the rod within the range of conditions calculated below.

$$M+T \leq 120 \text{ (N} \cdot \text{m)}$$

$$\text{Moment Load } M = Wg \times L_2$$

$$\text{Load Torque } T = Wg \times L_1$$

\* g = Gravitational acceleration 9.8

\* L1 = Distance from the center of rod to the center of gravity of the work piece

\* L2 = Distance from the actuator mounting surface to the center of gravity of the work piece + 0.07

If the above condition is not met, consider installing an external guide, or the like, so that the load is not exerted on the rod.