# Selection guide

| Units and symbols of operation conditions | |
|---|---|
| Load moment of inertia ($kg\cdot m^2$) | J |
| Travel angle (°) | ψ |
| Travel time (s) | $t_1$ |
| Cycle time (s) | $t_0$ |
| Load friction torque (N·m) | $T_F$ |
| Work torque (N·m) | $T_W$ |
| Cam curve | Select from (MS, MC, MT, TR) |

## 1. Moment of inertia of load

Calculate the moment of inertia of load and temporarily select an actuator that can allow the moment of inertia.

## 2. Rotation speed

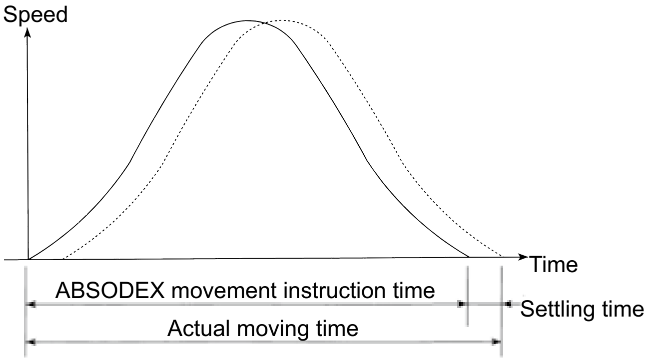
The max. rotation speed Nmax is obtained by the formula:

$$N_{max} = V_m \cdot \frac{\psi}{6 \cdot t_1} \quad \text{(rpm)}$$

Where ψ and $t_1$ represent travel angle (°) and travel time (s), respectively. $V_m$ is a constant determined by the cam curve.

Check that the value of Nmax dose not exceed the max. rotation speed defined in the actuator specifications.

[Precautions]
The actual travel time is the directive travel time of the ABSODEX plus the stabilization time.




Though the stabilization time depends on working conditions, it is approximately between 0.025 and 0.2 seconds.
For the travel time $t_1$ in model selection, use the directive travel time of ABSODEX. Also, for setting the travel time with an NC program, use the directive travel time of ABSODEX.

(Note) The friction torque works on the output shaft by the bearing, sliding surface, and other friction. The friction torque can be obtained by the following relational expression:

$T_f = \mu \cdot F_f \cdot R_f$ (N·m)

$F_f = m \cdot g$

where $\mu$: Coefficient of friction

| Rolling friction | Sliding friction |
|---|---|
| $\mu$ = 0.03 to 0.05 | $\mu$ = 0.1 to 0.3 |

Ff : Force working on the sliding surface, bearing, etc. (N)
Rf : Average friction radius (m)
m : Weight (kg)
g : Gravity acceleration ($m/s^2$)

## 3. Load torque

a) The maximum load torque is obtained with the following formula.

$$T_m = [A_m \cdot (J+J_M) \cdot \frac{\psi \cdot \pi}{180 \cdot t_1^2} + T_F + T_W] \cdot fc + T_{MF}$$

b) The effective value of the load torque is obtained with the following formula.

$$T_{rms} = \sqrt{\frac{t_1}{t_0} \cdot [r \cdot A_m \cdot (J+J_M) \cdot \frac{\psi \cdot \pi}{180 \cdot t_1^2} \cdot fc]^2 + (T_F \cdot fc + T_W \cdot fc + T_{MF})^2}$$

The values in the following table are applied to Vm, Am and r.

| Cam curve | $V_m$ | $A_m$ | r |
|---|---|---|---|
| MS | 1.76 | 5.53 | 0.707 |
| MC | 1.28 | 8.01 | 0.500 |
| MT | 2.00 | 4.89 | 0.866 |
| TR | 2.18 | 6.17 | 0.773 |

$J_M$, $T_{MF}$, fc are as follows:

$J_M$ : Output shaft moment of inertia ($kg\cdot m^2$)
$T_{MF}$ : Output shaft friction torque (N·m)
fc : Used factor (For normal use: fc = 1.5)

For the temporarily selected actuator,
Max. load torque < Max. output torque
Effective value of load torque < Continuous output torque
If either of the above conditions is not met, re-calculate the load torque with a larger actuator.

Note) There is a torque limit region where the max. torque decreases at the time of high-speed rotation.
For use in the torque limit region, use the mode selection software to determine the availability of the device.

(Note) The work torque indicates an exterior load, expressed as torque, working as the load on the ABSODEX output shaft.

The work torque Tw is calculated by the following formula:

$T_W = F_W \times R_W$ (N·m)

$F_W$ (N) : Necessary force for work
$R_W$ (m) : Working radius

(Example)
For the body on its side (the output shaft in the horizontal direction), the table, workpiece, jigs and so forth are work torques.

## 4. Regenerative power

For AX9000TS/AX9000TH and AX9000XS drivers, calculate the regenerative power using the following simple formula and determine the availability.

### ● For AX9000TS/AX9000XS drivers

AX9000TS type drivers and AX9000XS type drivers do not come with a built-in regenerative resister.
Therefore, check that the value of the regenerative energy calculated by the simple formula below does not exceed energy chargeable with a capacitor (table below).

$$E = \left(\frac{V_m \cdot \psi \cdot \pi}{t_1 \cdot 180}\right)^2 \cdot \frac{(J+J_M)}{2} \text{ (J)}$$

| Power specifications | Processable regenerative energy (J) | Remarks |
|---|---|---|
| 200 VAC | 17.2 | Value when the input voltage of the main power is 200 VAC |
| 100 VAC (-J1) | 17.2 | Value when the input voltage of the main power is 100 VAC |

If this condition is not met, contact CKD.

### ● For AX9000TH drivers

AX9000TH drivers have limitation on the consumption capability of the regenerative power in the driver.
The value is obtained by the following simple formula:

$$W = \left(\frac{V_m \cdot \psi \cdot \pi}{t_1 \cdot 180}\right)^2 \cdot \frac{(J+J_M)}{2 \cdot t_0} \text{ (W)}$$

$W \leq 40$

If this condition is met, re-consider the operation conditions and load conditions.

| [Working conditions] | | [Operating conditions] | |
|---|---|---|---|
| Table radius | : R = 0.4 (m) | Travel angle | : $\psi$ = 90 (°) |
| Table weight | : Wt = 79 (kg) | Travel time | : $t_1$ = 0.8 (s) |
| Radius of jig rotation | : Re = 0.325 (m) | Cycle time | : $t_0$ = 4 (s) |
| Jig weight | : Wj = 10 (kg/piece) (Including the workpiece weight) | Load friction torque | : $T_F$ = 0 (N·m) |
| | | Work torque | : $T_W$ = 0 (N·m) |
| Number of jigs | : N = 4 | Output shaft friction torque | : $T_{MF}$ (N·m) According to the actuator specifications |
| | | Cam curve | : MS (modified sine) |

## STEP 1
### Calculating moment of inertia

a) Table $J_1 = \frac{W_t \times R^2}{2} = \frac{79 \times 0.4^2}{2} = 6.32$ (kg·m²)

b) Jig, workpiece $J_2 = N \times W_j \times R_e^2 = 4 \times 10 \times 0.325^2 = 4.225$ (kg·m²)

c) Sum of moment of inertia $J = J_1 + J_2 = 6.32 + 4.225 = 10.545$ (kg·m²)

## STEP 2
### Max. rotation speed

$$N_{max} = V_m \cdot \frac{\psi}{6 \cdot t_1} = 1.76 \times \frac{90}{6 \times 0.8} = 33 \text{ (rpm)}$$

Check that $N_{max}$ does not exceed the maximum rotation speed of ABSODEX.

## STEP 3
### Load torque

At first, perform calculation for the smallest model that allows the moment of inertia of load.

The allowed moment of inertia of AX4300T is 180 (kg·m²), which means that this load is allowed.

Max. load torque

$$T_m = [A_m \cdot (J + J_M) \cdot \frac{\psi \cdot \pi}{180 \cdot t_1^2} + T_F + T_W] \cdot fc + T_{MF}$$

$$= [5.53 \times (10.545 + 0.326) \times \frac{90 \times \pi}{180 \cdot 0.8^2} + 0 + 0] \times 1.5 + 10$$

$$= 231.3 \text{ (N·m)}$$

Effective value of load torque

$$T_{rms} = \sqrt{\frac{t_1}{t_0} \cdot [r \cdot A_m \cdot (J + J_M) \cdot \frac{\psi \cdot \pi}{180 \cdot t_1^2} \cdot fc]^2 + (T_F \cdot fc + T_W \cdot fc + T_{MF})^2}$$

$$T_{rms} = \sqrt{\frac{0.8}{4} \times [0.707 \times 5.53 \times 10.871 \times \frac{90 \times \pi}{180 \cdot 0.8^2} \times 1.5]^2 + (0 \times 1.5 + 0 \times 1.5 + 10)^2}$$

$$= 70.7 \text{ (N·m)}$$

## STEP 4
### Regenerative power

$$W = \left(\frac{V_m \cdot \psi \cdot \pi}{t_1 \cdot 180}\right)^2 \cdot \frac{(J+J_M)}{2 \cdot t_0}$$

$$= \left(\frac{1.76 \times 90 \times \pi}{0.8 \times 180}\right)^2 \times \frac{10.871}{2 \times 4} = 16.23 \text{ (W)}$$

$W \leq 40$ (W)

## STEP 5
### Selection guide

Consider whether the temporarily selected AX4300T is available.

| | |
|---|---|
| Sum of the moment of inertia of load | 10.545 ≤ 180 (kg·m²) |
| Max. rotation speed | 33 ≤ 100 (rpm) |
| Max. load torque | 231.3 ≤ 300 (N·m) |
| Effective value of load torque | 70.7 ≤ 100 (N·m) |
| Regenerative power | 16.23 ≤ 40 (J) |

Under these conditions, AX4300T is available.

| [Working conditions] | | [Operating conditions] | |
|---|---|---|---|
| Table radius | : $R = 0.25$ (m) | Travel angle | : $\psi = 90$ (°) |
| Table weight | : $Wt = 10.6$ (kg) | Travel time | : $t_1 = 0.5$ (s) |
| Radius of jig rotation | : $Re = 0.2$ (m) | Cycle time | : $t_0 = 4$ (s) |
| Jig weight | : $Wj = 2$ (kg/piece) (Including the workpiece weight) | Load friction torque | : $T_F = 0$ (N·m) |
| Number of jigs | : $N = 4$ | Work torque | : $T_W = 0$ (N·m) |
| | | Output shaft friction torque | : $T_{MF}$ (N·m) According to the actuator specifications |
| | | Cam curve | : MS (modified sine) |

## STEP 1
### Calculating moment of inertia

a) Table $J_1 = \frac{W_t \times R^2}{2} = \frac{10.6 \times 0.25^2}{2} = 0.331$ (kg·m²)

b) Jig, workpiece $J_2 = N \times W_j \times R_e^2 = 4 \times 2 \times 0.2^2 = 0.32$ (kg·m²)

c) Sum of moment of inertia $J = J_1 + J_2 = 0.331 + 0.32 = 0.651$ (kg·m²)

## STEP 2
### Max. rotation speed

$$N_{max} = V_m \cdot \frac{\psi}{6 \cdot t_1} = 1.76 \times \frac{90}{6 \times 0.5} = 52.8 \quad \text{(rpm)}$$

Check that $N_{max}$ does not exceed the maximum rotation speed of ABSODEX.

## STEP 3
### Load torque

At first, perform calculation for the smallest model that allows the moment of inertia of load.
The allowed moment of inertia of AX7045X is 0.90 (kg·m²), which means that this load is allowed.

Max. load torque

$$T_m = [A_m \cdot (J+J_M) \cdot \frac{\psi \cdot \pi}{180 \cdot t_1^2} + T_F + T_W] \cdot fc + T_{MF}$$

$$= [5.53 \times (0.651 + 0.0254) \times \frac{90 \times \pi}{180 \cdot 0.5^2} + 0 + 0] \times 1.5 + 2.5$$

$$= 37.8 \text{ (N·m)}$$

Effective value of load torque

$$T_{rms} = \sqrt{\frac{t_1}{t_0} \cdot [r \cdot A_m \cdot (J + J_M) \cdot \frac{\psi \cdot \pi}{180 \cdot t_1^2} \cdot fc]^2 + (T_F \cdot fc + T_W \cdot fc + T_{MF})^2}$$

$$T_{rms} = \sqrt{\frac{0.5}{4} \times [0.707 \times 5.53 \times 0.6764 \times \frac{90 \times \pi}{180 \cdot 0.5^2} \times 1.5]^2 + (0 \times 1.5 + 0 \times 1.5 + 2.5)^2}$$

$$= 9.2 \text{ (N·m)}$$

## STEP 4
### Regenerative power

$$E = \left(\frac{V_m \cdot \psi \cdot \pi}{t_1 \cdot 180}\right)^2 \cdot \frac{(J+J_M)}{2} \text{ (J)}$$

$$= \left(\frac{1.76 \times 90 \times \pi}{0.5 \times 180}\right)^2 \times \frac{0.6764}{2} = 10.3 \text{ (J)}$$

$E \leq 17.2$ (J)

## STEP 5
### Selection guide

Consider whether the temporarily selected AX7045X is available.

| | |
|---|---|
| Sum of the moment of inertia of load | $0.651 \leq 0.90$ (kg·m²) |
| Max. rotation speed | $52.8 \leq 240$ (rpm) |
| Max. load torque | $37.8 \leq 45$ (N·m) |
| Effective value of load torque | $9.2 \leq 15$ (N·m) |
| Regenerative power | $10.3 \leq 17.2$ (J) |

With these conditions, AX7045X is available.

Selection guide (2)

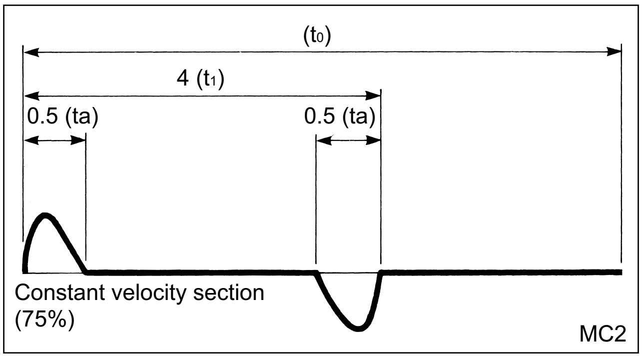
## For model selection for "MC2 curve"

### What is MC2 curve?

The MC2 curve is a cam curve for which the constant velocity interval can be freely set by setting the acceleration/deceleration time while there is a constant velocity interval during travel, as is the case with an MC (modified constant) curve.
For an MC (generic term: MCV50) curve, the percentage of the constant velocity interval is 50%.

Note: The setting of the acceleration/deceleration time is 1/2 or less of the travel time. When the setting of the acceleration/deceleration time exceeds 1/2 of the travel time, the cam curve is automatically changed to the MS (modified sine) curve.

The example diagram shows the velocity pattern when the percentage of the constant velocity interval is 75% by setting the acceleration/deceleration time (ta) to 0.5 seconds for the 4 seconds of the travel time ($t_1$).




### Selection method

For the MC2 curve, the formula below is used to select a model.

| | |
|---|---|
| Travel angle | : $\psi$ (°) |
| Cycle time | : $t_0$ (s) |
| Travel time | : $t_1$ (s) |
| Acceleration/deceleration time | : ta (s) |
| Load moment of inertia | : J (kg·m²) |
| Output shaft moment of inertia | : $J_M$ (kg·m²) |
| Friction torque | : Tf (N·m) |
| Work torque | : $T_w$ (N·m) |
| Output shaft friction torque | : $T_{MF}$ (N·m) |

Max. rotation speed: Nmax (rpm)

$$Nmax = \frac{\psi}{6\,(t_1 - 0.863ta)}$$

Load torque (max. value): $T_m$ (N·m)

$$Tm = \left[ 5.53\,(J+J_M) \cdot \frac{\psi \cdot \left(1 - \frac{t_1 - 2ta}{t_1 - 0.863ta}\right) \cdot \pi}{720 \cdot ta^2} + Tf + T_w \right] \cdot fc + T_{MF}$$

Load torque (effective value): Trms (N·m)

$$Trms = \sqrt{\frac{2ta}{t_0} \cdot \left[ 3.91\,(J+J_M) \cdot \frac{\psi \cdot \left(1 - \frac{t_1 - 2ta}{t_1 - 0.863ta}\right) \cdot \pi}{720 \cdot ta^2} \cdot fc \right]^2 + \left[(Tf+T_w) \cdot fc + T_{MF}\right]^2}$$

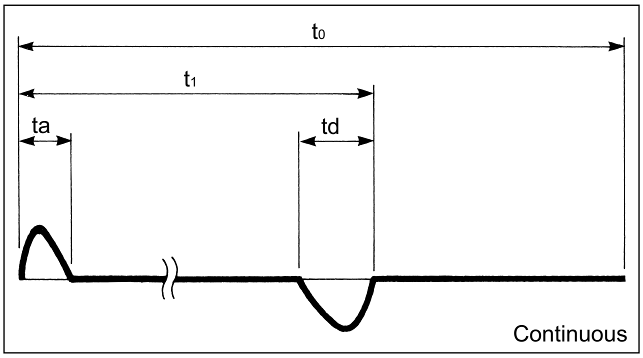
## For model selection for "Continuous rotation"

### What is continuous rotation?

The continuous rotation has the following functions.

1. Continuous rotation : Rotation continues at a constant rotation speed until the continuous rotation stop input is input.
2. Stop at equal segment position : With the equal segment specified, the device stops at the equal segment position by a continuous rotation stop input.

The example diagram shows the velocity pattern where the motor is accelerated at the acceleration time: ta up to the set rotation speed: N, and then stopped, by a continuous rotation stop input, at the deceleration time: td.




### Selection method

For the continuous rotation, the formula below is used to select a model.

| | |
|---|---|
| Rotation speed | : N (rpm) |
| Cycle time | : $t_0$ (s) |
| Acceleration time | : ta (s) |
| Deceleration time | : td (s) |
| Load moment of inertia | : J (kg·m²) |
| Output shaft moment of inertia | : $J_M$ (kg·m²) |
| Friction torque | : Tf (N·m) |
| Work torque | : $T_w$ (N·m) |
| Output shaft friction torque | : $T_{MF}$ (N·m) |

Max. rotation speed: Nmax (rpm) (*1)

Nmax = N

Load torque (max. value): Tm (N·m)

$$Tm = \left[ 5.53\,(J+J_M) \cdot \frac{6.82N \cdot ta \cdot \pi}{720 \cdot ta^2} + Tf + T_w \right] \cdot fc + T_{MF}$$

Load torque (effective value): Trms (N·m)

$$Trms = \sqrt{\frac{2ta}{t_0} \cdot \left[ 3.91\,(J+J_M) \cdot \frac{6.82N \cdot ta \cdot \pi}{720 \cdot ta^2} \cdot fc \right]^2 + \left[(Tf+T_w) \cdot fc + T_{MF}\right]^2}$$

The formula above is applicable when ta ≤ td. When ta > td, replace ta with td for perform selection.

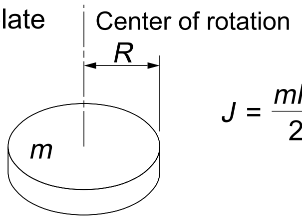
*1) At the time of continuous rotation, the maximum rotation speed is limited. Use the device according to the actuator specifications.

## Formulas of moment of inertia

( $m$ : Weight of object (kg) )

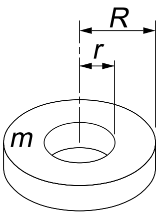
### ● A When rotation center is own shaft

1. Circular plate (cylinder)



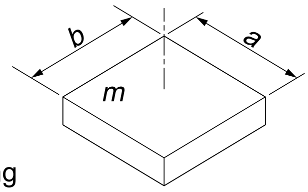

$$J = \frac{mR^2}{2}$$

2. Hollow circular plate (hollow cylinder)



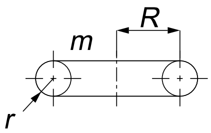

$$J = \frac{m\,(R^2 + r^2)}{2}$$

3. Cuboid



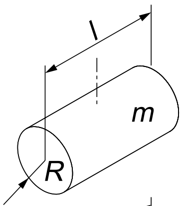

$$J = \frac{m\,(a^2 + b^2)}{12}$$

4. Ring



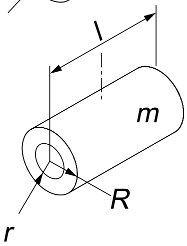

$$J = \frac{m\,(4R^2 + 3r^2)}{4}$$

5. Cylinder




$$J = \frac{m\,(3R^2 + l^2)}{12}$$

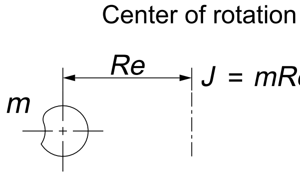
6. Hollow cylinder




$$J = \frac{m\,(R^2 + r^2 + l^2/3)}{4}$$

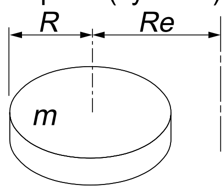
### ● B When rotation center differs from own shaft

1. Any shape (if sufficiently small)



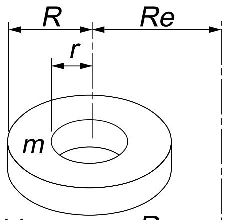

$$J = mRe^2$$

2. Circular plate (cylinder)



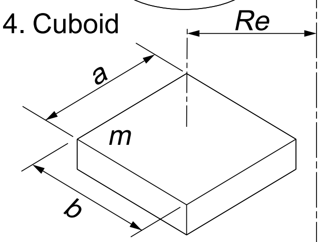

$$J = m\left(\frac{R^2}{2} + Re^2\right)$$

3. Hollow circular plate (hollow cylinder)



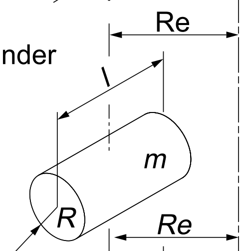

$$J = m\left(\frac{R^2 + r^2}{2} + Re^2\right)$$

4. Cuboid



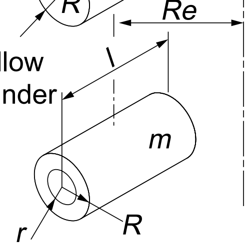

$$J = m\left(\frac{a^2 + b^2}{12} + Re^2\right)$$

5. Cylinder



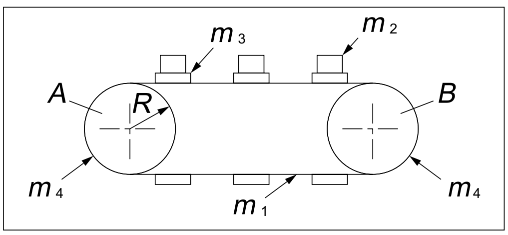

$$J = m\left(\frac{3R^2 + l^2}{12} + Re^2\right)$$

6. Hollow cylinder




$$J = m\left(\frac{R^2 + r^2 + l^2/3}{4} + Re^2\right)$$

### ● For conveyor




$m_1$ : Chain weight
$m_2$ : Workpiece total weight
$m_3$ : Jig (pallet) total weight
$m_4$ : Sprocket A (drive) + B total weight
$R$ : Drive side sprocket radius

$$J = \left(m_1 + m_2 + m_3 + \frac{m_4}{2}\right) \cdot R^2$$

| ABSODEX selection guide specifications check sheet<br>Table direct drive | | (Note) Contact CKD for chain drives and gear drives. | |
|---|---|---|---|
| Company name | | Your name | |
| Division | | | |
| TEL | | FAX | |

■ Operating conditions

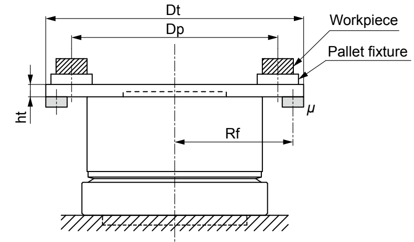
1. Index 2. Oscillator
Movement angle Ψ (°) ______ or No. of indexes ______
Movement time $t_1$ (sec.) ______
Cycle time $t_0$ (sec.) ______ cycle time=moving time+dwelling time
(Note) Index time is movement time + settling time.
The settling time differs according to the working condition, but generally is between 0.025 and 0.20 s.

■ Load conditions

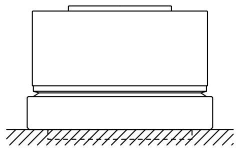
Table
Material 1. Steel 2. Aluminum ______
Outline Dt (mm) ______
Plate thickness ht (mm) ______
Weight m1 (kg) ______

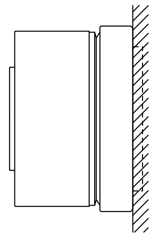
Workpiece
Quantity nw (pc.) ______
Max. weight mw (kg/pc.) ______
Installation center Dp (mm) ______

Pallet fixture
Quantity np (pc.) ______
Max. weight mp (kg/pc.) ______



(Fig. 1) Load conditions


(Fig. 2) Installation position: Horizontal


(Fig. 3) Installation position: Vertical

■ Other load conditions

Installation position
1. Horizontal (Fig.2) 2. Vertical (Fig. 3) ______

Extemal job
1. None 2. Available ______
(Note) Eccentric load caused by gravity from vertical installation, extemal load caused by caulking work

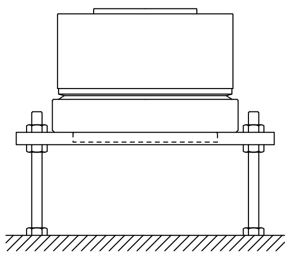
Dial plate support form bottom
1. None 2. Available ______
Coefficient of friction μ ______
Work radius Rf (mm) ______

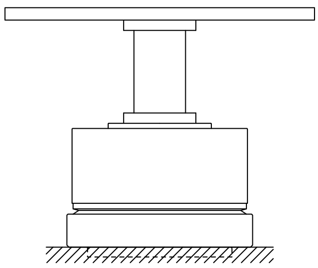
Device rigidity
1. High 2. Low (Note) ______
(Note) When using a spline, when unit cannot be fixed directly onto the device (Fig. 4), when there is a mechanism such as a chuck on the table.

Extension with table shaft
1. None 2. Available (Fig. 5) ______

Actuator movement
1. None 2. Available ______
(Note) When actuator is mounted on X-Y table or vertical mechanism, etc., and mounted actuator moves

(Note) If 2 is selected for any item, contact CKD.


(Fig. 4) Installation rigidity: Low


(Fig. 5) Extension with shaft

(Note) Attach system outline and reference drawings so that the optimal model can be selected.

■ Use conditions, environmental conditions (Optional)

Actuator ambient temperature (°C) ______
Motor cable length (m) ______

Driver ambient temperature (°C) ______
24 VDC power supply cable length (m) ______
24 VDC power supply coil diameter ($mm^2$) ______
24 VDC power supply voltage accuracy (%) ______
24 VDC line point of contact quantity (pc.) ______
24 VDC line point of contact resistance (mΩ / pc.) ______

* You can do a more rigorous selection by filling in this field.
* With a power supply cable 1.25 mm² or more, please use one as short (recommended length 1 m or less) as possible.
* If the output voltage is low in a power supply with voltage adjustment, please adjust it to 24 V and use it.