Selection Calculations For Motorized Actuators

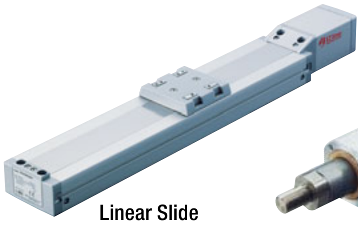
Motorized Linear Slides and Cylinders

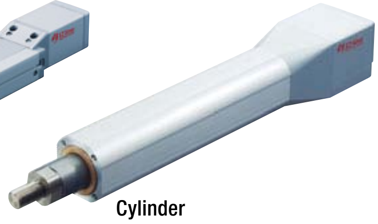
Select from the EZSII Series, EZSII Series for Cleanroom Use, EZCII Series

First determine your series, then select your model.
Select the actuator that you will use based on the following flow charts:

1 Determine the Actuator Type

Select the actuator type that you will use.
(Linear slide type and cylinder type)


Linear Slide


Cylinder

2 Check the Actuator Size and Transport Mass

Select the cylinder and linear slide size that satisfies your desired conditions. (Check the frame size, table height, transport mass and thrust force.)

3 Check the positioning time

Check whether your desired positioning time is sufficient using the "Positioning Distance – Positioning Time" graph.
As a reference, the positioning time by the linear slide corresponds to the positioning time calculated from the graph, multiplied by the "positioning time coefficient" corresponding to the applicable stroke.

4 Check the Operating Conditions

Check that the operating speed and acceleration satisfy the 3 conditions using the "Positioning Distance – Operating Speed"✻ and "Positioning Distance – Acceleration"✻ graphs.

5 Check the Moment (Linear slide only)

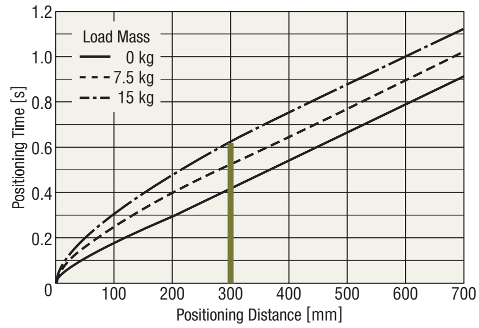
Take into account the calculated acceleration conditions and check that the dynamic permissible moment applied to the motorized linear slide is not exceeded.
Refer to the following page for the moment calculation methods.

Selection complete

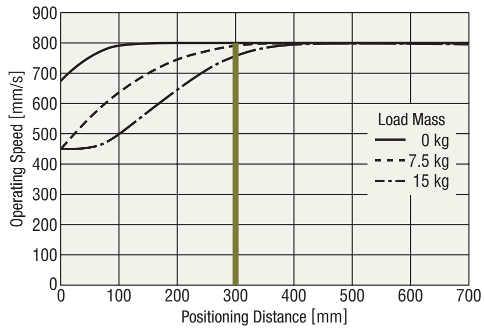
✻Check the Oriental Motor website.

Example): Check of the operating speed and acceleration in order to execute the positioning time and this operation at a positioning distance of 300 mm.

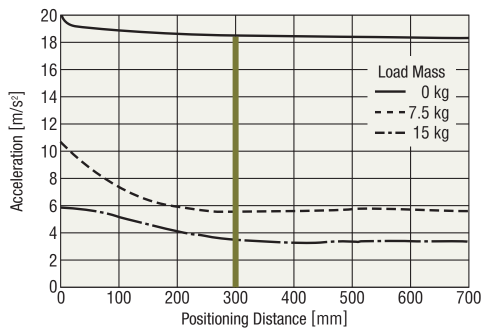
• Positioning Distance – Positioning Time (Horizontal)



• Positioning Distance – Operating Speed (Horizontal)



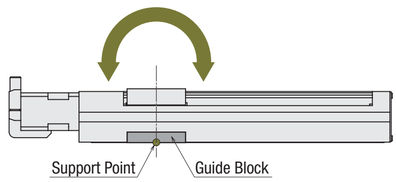
• Positioning Distance – Acceleration (Horizontal)



Calculating Load Moment

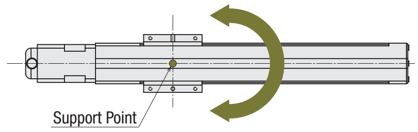
When a load is transported with the motorized linear slides, the load moment acts on the linear guide if the load position is offset from the center of the table. The direction of action applies to three directions, (pitching (M_P), yawing (M_Y), and rolling (M_R) depending on the position of the offset.

Pitching Direction (M_P)



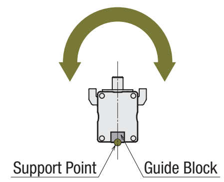
(Linear slide bottom face, center of table)

Yawing Direction (M_Y)



(Center of table)

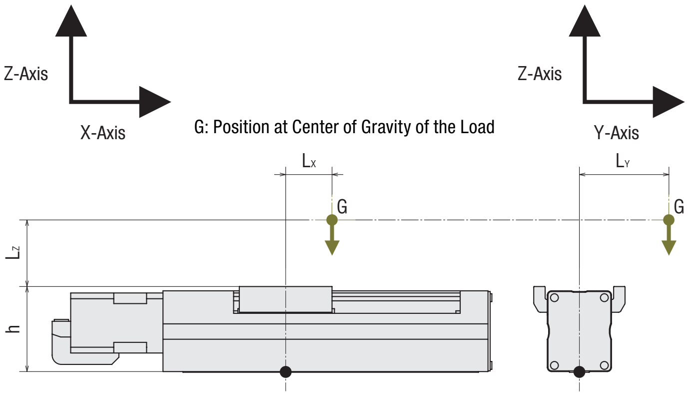
Rolling Direction (M_R)



(Linear slide bottom face, center of table)

Even though the selected actuator satisfies the transport mass and positioning time, when the fixed load is overhung from the table, the run life may decrease as a result of the load moment. It is necessary to check if load moment calculations are not done, and if conditions are within the specified values. Check the moment applied under static conditions with the static permissible moment, and the moment applied under movement with the dynamic permissible moment.

Calculate the load moment of the linear slide based on loads. Check that the static permissible moment and dynamic permissible moment are within limits and check that strength is sufficient.



m: Load mass (kg)
g : Gravitational acceleration 9.807 (m/s²)
a : Acceleration (m/s²)
h : Linear slide table height (m)

L_X: Overhung distance in the direction of the X-axis (m)
L_Y: Overhung distance in the direction of the Y-axis (m)
L_Z: Overhung distance in the direction of the Z-axis (m)

ΔM_P: Load moment in the pitching direction (N·m)
ΔM_Y: Load moment in the yawing direction (N·m)
ΔM_R: Load moment in the rolling direction (N·m)

Load Moment Formula:

$$\frac{|\Delta M_P|}{M_P}+\frac{|\Delta M_Y|}{M_Y}+\frac{|\Delta M_R|}{M_R}\leqq 1$$

When there are several overhung loads, etc., this equation determines the moment from all loads.

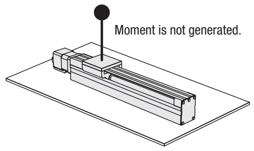
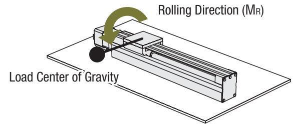
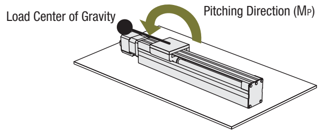
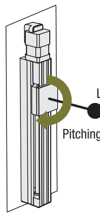
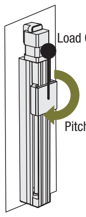
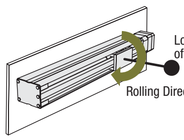
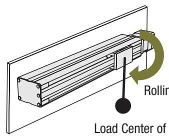
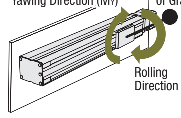
For Multiple Loads (n)

$$\frac{|\Delta M_{P1}+\Delta M_{P2}+\cdots\Delta M_{Pn}|}{M_P}+\frac{|\Delta M_{Y1}+\Delta M_{Y2}+\cdots\Delta M_{Yn}|}{M_Y}+\frac{|\Delta M_{R1}+\Delta M_{R2}+\cdots\Delta M_{Rn}|}{M_R}\leqq 1$$

Selection Calculations
Motors
Motorized Actuators
Cooling Fans
Service Life
Standard AC Motors
Speed Control Motors
Stepping Motors
Servo Motors
Gearheads
Linear Heads
Motorized Actuators
Cooling Fans

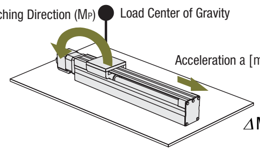
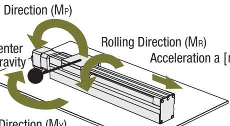
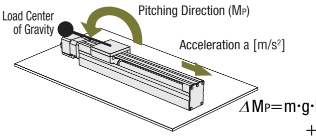
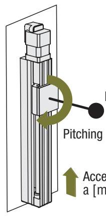
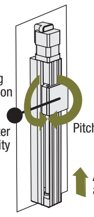
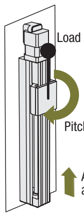
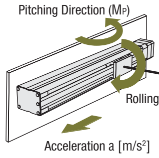
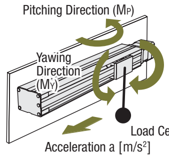
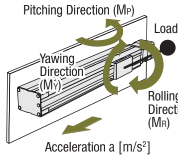
●Concept of Static Moment Application

Check the static permissible moment when the load moment is applied to the stopped linear slide and compare it with the static permissible moment or the maximum load moment.

Horizontal		 $\Delta M_R = m \cdot g \cdot L_Y$ $\quad \frac{\lvert \Delta M_R \rvert}{M_R} \leqq 1$	 $\Delta M_P = m \cdot g \cdot L_X$ $\quad \frac{\lvert \Delta M_P \rvert}{M_P} \leqq 1$
Vertical	 $\Delta M_P = m \cdot g \cdot (L_Z + h)$ $\frac{\lvert \Delta M_P \rvert}{M_P} \leqq 1$	 $\Delta M_P = m \cdot g \cdot (L_Z + h)$ $\Delta M_Y = m \cdot g \cdot L_Y$ $\frac{\lvert \Delta M_P \rvert}{M_P} + \frac{\lvert \Delta M_Y \rvert}{M_Y} \leqq 1$	 $\Delta M_P = m \cdot g \cdot (L_Z + h)$ $\frac{\lvert \Delta M_P \rvert}{M_P} \leqq 1$
Wall Installing	 $\Delta M_R = m \cdot g \cdot (L_Z + h)$ $\frac{\lvert \Delta M_R \rvert}{M_R} \leqq 1$	 $\Delta M_R = m \cdot g \cdot (L_Z + h)$ $\frac{\lvert \Delta M_R \rvert}{M_R} \leqq 1$	 $\Delta M_Y = m \cdot g \cdot L_X$ $\Delta M_R = m \cdot g \cdot (L_Z + h)$ $\frac{\lvert \Delta M_Y \rvert}{M_Y} + \frac{\lvert \Delta M_R \rvert}{M_R} \leqq 1$

●Concept of Dynamic Moment Application

When the load moment is applied during linear slide operation, take into account the acceleration and check that the dynamic moment is not exceeded and compare it with the dynamic permissible moment or the maximum load moment.

Horizontal	 $\Delta M_P = m \cdot a \cdot (L_Z + h)$ $\frac{\lvert \Delta M_P \rvert}{M_P} \leqq 1$	 $\Delta M_P = m \cdot a \cdot (L_Z + h)$ $\Delta M_Y = m \cdot a \cdot L_Y$ $\Delta M_R = m \cdot g \cdot L_Y$ $\frac{\lvert \Delta M_P \rvert}{M_P} + \frac{\lvert \Delta M_Y \rvert}{M_Y} + \frac{\lvert \Delta M_R \rvert}{M_R} \leqq 1$	 $\Delta M_P = m \cdot g \cdot L_X + m \cdot a \cdot (L_Z + h)$ $\frac{\lvert \Delta M_P \rvert}{M_P} \leqq 1$
Vertical	 $\Delta M_P = m \cdot g \cdot (L_Z + h) + m \cdot a \cdot (L_Z + h)$ $\frac{\lvert \Delta M_P \rvert}{M_P} \leqq 1$	 $\Delta M_P = m \cdot g \cdot (L_Z + h) + m \cdot a \cdot (L_Z + h)$ $\Delta M_Y = m \cdot g \cdot L_Y + m \cdot a \cdot L_Y$ $\frac{\lvert \Delta M_P \rvert}{M_P} + \frac{\lvert \Delta M_Y \rvert}{M_Y} \leqq 1$	 $\Delta M_P = m \cdot g \cdot (L_Z + h) + m \cdot a \cdot (L_Z + h)$ $\frac{\lvert \Delta M_P \rvert}{M_P} \leqq 1$
Wall Installing	 $\Delta M_P = m \cdot a \cdot (L_Z + h)$ $\Delta M_R = m \cdot g \cdot (L_Z + h)$ $\frac{\lvert \Delta M_P \rvert}{M_P} + \frac{\lvert \Delta M_R \rvert}{M_R} \leqq 1$	 $\Delta M_P = m \cdot a \cdot (L_Z + h)$ $\Delta M_Y = m \cdot a \cdot L_Y$ $\Delta M_R = m \cdot g \cdot (L_Z + h)$ $\frac{\lvert \Delta M_P \rvert}{M_P} + \frac{\lvert \Delta M_Y \rvert}{M_Y} + \frac{\lvert \Delta M_R \rvert}{M_R} \leqq 1$	 $\Delta M_P = m \cdot a \cdot (L_Z + h)$ $\Delta M_Y = m \cdot g \cdot L_X$ $\Delta M_R = m \cdot g \cdot (L_Z + h)$ $\frac{\lvert \Delta M_P \rvert}{M_P} + \frac{\lvert \Delta M_Y \rvert}{M_Y} + \frac{\lvert \Delta M_R \rvert}{M_R} \leqq 1$

The linear guide of the linear slide is designed with an expected life of respective series' reference values. However, when the load factor of the load moment for the calculated static and dynamic permissible moment or maximum load moment is 1 or more, the expected life distance is below. How much of the expected life distance can be checked in the formula below.

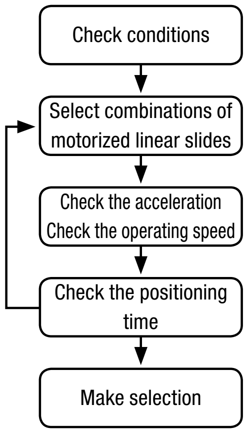
$$\text{Expected life (km)} = \text{References on service life of each series}^{*} \times \left(\frac{1}{\frac{\lvert \Delta M_P \rvert}{M_P} + \frac{\lvert \Delta M_Y \rvert}{M_Y} + \frac{\lvert \Delta M_R \rvert}{M_R}} \right)^3$$

✽For references on service life of each series, refer to page H-29 "● Concept of Service Life."

Selection of Dual Axis Installation Brackets from the **EZSII** Series

This section is about selecting a dedicated **EZSII** Series dual axis installation bracket.
Select a dual axis combination from the **EZSII** Series that meets your requirements, then select a dual axis installation bracket for these requirements.
Following the flow chart while checking the conditions will allow you to select the ideal combination.

Selection Flow Chart



Select the motorized linear slides combinations from the "Transportable Mass per Acceleration" table, and determine the required dual axis installation bracket for these combinations.

Calculate the acceleration from the "Transportable Mass per Acceleration" table, and check the speed of each shaft from the Speed – Transportable Mass graph.

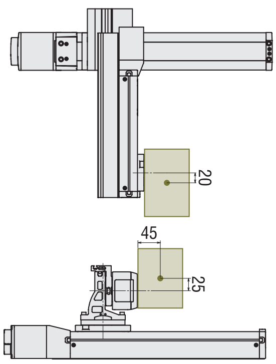
Calculate the positioning time. Check whether or not your desired positioning times are sufficient.

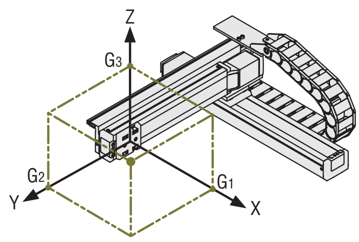
Selection Example

Follow the flow chart and select a dual axis installation bracket based on the following conditions:

Condition

Transports 2.5 kg a distance of 125 mm in 0.5 s with X-Y installation
A moving range of 500 mm for the X-axis and 250 mm for the Y-axis
The center of gravity of the load for the Y-axis is (G1, G2, G3)=(45, 20, 25)
Power supply voltage is single-phase 220 VAC





(1) Select the Linear Slide Combinations and Dual Axis Installation Bracket

Check the motorized linear slides combinations from the "Transportable Mass per Acceleration" table. (Refer to Page H-23.)
The absolute value within G1, G2 and G3 is calculated as the largest value.
Under these conditions, since | G1 | =45 is the maximum value,
refer to the table of the center of gravity condition 30 < | Gn | ≦ 50.
The linear slide combinations that have a transportable mass of 2.5 kg with a stroke of 250 mm are as follows:

Combination 1: X-Axis: **EZS6D** Y-Axis: **EZS3D**
or
Combination 2: X-Axis: **EZS6D** Y-Axis: **EZS4D**

For smaller sized products, select "Combination 1."

The following products were tentatively selected:

X-Axis: **EZS6D050-C**
Y-Axis: **EZS3D025-C**

Tentatively select **EZS6D** for the first axis and **EZS3D** for the second axis.
The combination pattern (refer to page E-97) for a 250 mm second axis stroke is an **R** Type. As a result, the required dual axis installation bracket will be **PAB-S6S3R025**.

(2) Check the Acceleration of the Linear Slide

Check the acceleration from the "Transportable Mass per Acceleration" table.
The maximum acceleration with a transportable mass of 2.5 kg will be 5 m/s².

Transportable Mass per Acceleration

X-Y Installation　Y-Axis Transportable Mass [kg]

		30 < | Gn | ≦ 50					
	Acceleration	Stroke [mm]					
		50	100	150	200	250	300
X-Axis: **EZS4D** Y-Axis: **EZS3D**	1.0 m/s²	2.0	1.6	1.3	1.0	0.7	0.4
	2.5 m/s²	1.1	0.8	0.5	0.2	–	–
	5.0 m/s²	0.3	–	–	–	–	–
	Acceleration	Stroke [mm]					
		50	100	150	200	250	300
X-Axis: **EZS6D** Y-Axis: **EZS3D**	1.0 m/s²	4.1	4.1	4.1	4.1	4.1	4.1
	2.5 m/s²	3.3	3.3	3.3	3.3	3.3	3.3
	5.0 m/s²	2.6	2.6	2.6	2.6	2.6	2.6
	Acceleration	Stroke [mm]					
		50	100	150	200	250	300
X-Axis: **EZS6D** Y-Axis: **EZS4D**	1.0 m/s²	8.7	8.7	8.7	8.1	7.0	6.0
	2.5 m/s²	7.0	7.0	7.0	6.3	5.3	4.5
	5.0 m/s²	5.3	5.3	5.2	4.3	3.6	2.9

X-Y Installation　Y-Axis Transportable Mass [kg]

		30 < | Gn | ≦ 50					
	Acceleration	Stroke [mm]					
		50	100	150	200	250	300
X-Axis: **EZS6D** Y-Axis: **EZS3D**	1.0 m/s²	4.1	4.1	4.1	4.1	4.1	4.1
	2.5 m/s²	3.3	3.3	3.3	3.3	3.3	3.3
	5.0 m/s²	2.6	2.6	2.6	2.6	2.6	2.6

(3) Check the Operating Speed of the Linear Slide

Check the "Speed – Transportable Mass Characteristics" graph. (Refer to page H-24.)
Draw a horizontal line indicating the 2.5 kg transportable mass of the Y-axis.
The point at which this line and the acceleration line at 5 m/s² intersect will be the maximum speed (upper limit) of dual axis combination.

X-Axis Speed: 460 mm/s or less
Y-Axis Speed: 560 mm/s or less

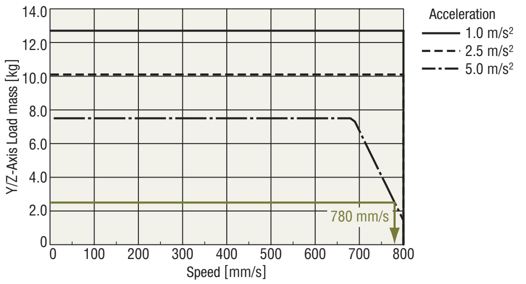
If using the combinable linear slides with greater size, the speed and acceleration can be improved despite having the same transportable mass.

●Speed – Transportable Mass

◇X-Axis Speed

●24 VDC

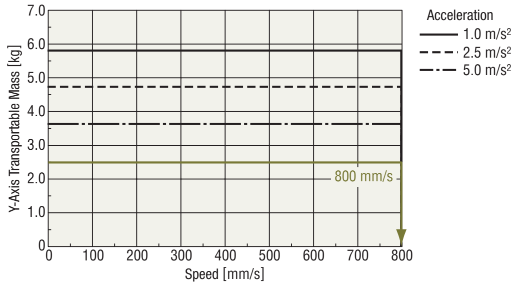
EZS6D□ (**M**) **-C**



◇Y-Axis Speed

●24 VDC

EZS3D□ (**M**) **-C**



(4) Check the Positioning Time

Easily calculate the positioning time, and check whether your desired positioning time is sufficient.
The friction formula is as follows:

●Check the operating pattern

$V_{Rmax} = \sqrt{L \cdot a \times 10^3}$

$V_{Rmax} \leqq V_R$ → Triangular Drive

$V_{Rmax} > V_R$ → Trapezoidal Drive

L : Positioning distance [mm]
a : Acceleration [m/s²]
V_R : Operating speed [mm/s]
V_{Rmax}: Maximum speed of triangular drive [mm/s]
T : Positioning time [s]

●Calculate the positioning time

<Triangular Drive>

$$T = \frac{2 \cdot V_{Rmax}}{a \times 10^3} \quad \text{or} \quad T = \sqrt{\frac{L}{a \times 10^3}} \times 2$$

<Trapezoidal Drive>

$$T = \frac{L}{V_R} + \frac{V_R}{a \times 10^3}$$

◇Example of Calculation

Try to check whether the 100 mm positioning distance at 0.5 second for the combinations on page H-21 can be moved.

X-Axis: EZS6D050-C

Condition
Speed V_R : 780 mm/s
Acceleration a : 5 m/s²
Positioning distance L : 125 mm

Check the operating pattern

$V_{Rmax} = \sqrt{125 \times 5 \times 10^3}$

$= 791 > V_R$ Trapezoidal Drive

Calculate the positioning time

$T = \frac{125}{780} + \frac{780}{5 \times 10^3}$

$= 0.316 \text{ s}$

Y-Axis: EZS3D025-C

Condition
Speed V_R : 800 mm/s
Acceleration a : 5 m/s²
Positioning distance L : 125 mm

Check the operating pattern

$V_{Rmax} = \sqrt{125 \times 5 \times 10^3}$

$= 791 \leqq V_R$ Triangular Drive

Calculate the positioning time

$T = \frac{2 \times 800}{5 \times 10^3}$

$= 0.320 \text{ s}$

The results of the calculation enable you to check that your desired positioning times are sufficient.

Transportable Mass per Acceleration

◇X-Y Installation　Y-Axis Transportable Mass [kg]

		|Gn| ≦ 30 [mm]						30 < |Gn| ≦ 50 [mm]						50 < |Gn| ≦ 100 [mm]					
	Acceleration	Stroke [mm]						Stroke [mm]						Stroke [mm]					
X-Axis: **EZS4D** Y-Axis: **EZS3D**		50	100	150	200	250	300	50	100	150	200	250	300	50	100	150	200	250	300
	1.0 m/s^2	2.3	1.9	1.5	1.1	0.7	0.4	2.0	1.6	1.3	1.0	0.7	0.4	1.5	1.2	1.0	0.7	0.5	0.3
	2.5 m/s^2	1.3	0.9	0.6	0.2	–	–	1.1	0.8	0.5	0.2	–	–	0.8	0.6	0.4	0.2	–	–
	5.0 m/s^2	0.3	–	–	–	–	–	0.3	–	–	–	–	–	0.2	–	–	–	–	–
	Acceleration	Stroke [mm]						Stroke [mm]						Stroke [mm]					
X-Axis: **EZS6D** Y-Axis: **EZS3D**		50	100	150	200	250	300	50	100	150	200	250	300	50	100	150	200	250	300
	1.0 m/s^2	5.8	5.8	5.8	5.8	5.8	5.8	4.1	4.1	4.1	4.1	4.1	4.1	2.3	2.3	2.3	2.3	2.3	2.3
	2.5 m/s^2	4.8	4.8	4.8	4.8	4.8	4.8	3.3	3.3	3.3	3.3	3.3	3.3	1.9	1.9	1.9	1.9	1.9	1.9
	5.0 m/s^2	3.6	3.6	3.6	3.6	3.6	3.6	2.6	2.6	2.6	2.6	2.6	2.6	1.5	1.5	1.5	1.5	1.5	1.5
	Acceleration	Stroke [mm]						Stroke [mm]						Stroke [mm]					
X-Axis: **EZS6D** Y-Axis: **EZS4D**		50	100	150	200	250	300	50	100	150	200	250	300	50	100	150	200	250	300
	1.0 m/s^2	12.7	12.4	10.4	8.9	7.6	6.5	8.7	8.7	8.7	8.1	7.0	6.0	4.8	4.8	4.8	4.8	4.8	4.8
	2.5 m/s^2	10.1	9.8	8.2	6.9	5.8	4.9	7.0	7.0	7.0	6.3	5.3	4.5	3.9	3.9	3.9	3.9	3.9	3.8
	5.0 m/s^2	7.5	7.1	5.8	4.7	3.9	3.1	5.3	5.3	5.2	4.3	3.6	2.9	3.0	3.0	3.0	3.0	3.0	2.5

◇X-Z Installation　Z-Axis Transportable Mass [kg]

		|Gn| ≦ 30 [mm]						30 < |Gn| ≦ 50 [mm]						50 < |Gn| ≦ 100 [mm]					
	Acceleration	Stroke [mm]						Stroke [mm]						Stroke [mm]					
X-Axis: **EZS4D** Z-Axis: **EZS3D**		50	100	150	200	250	300	50	100	150	200	250	300	50	100	150	200	250	300
	1.0 m/s^2	3.5	3.3	3.0	2.7	2.5	2.2	2.6	2.6	2.5	2.3	2.0	1.8	1.6	1.6	1.6	1.6	1.5	1.3
	2.5 m/s^2	2.1	1.7	1.4	1.0	0.7	0.4	1.7	1.4	1.2	0.9	0.6	0.4	1.2	1.0	0.8	0.7	0.5	0.3
	5.0 m/s^2	0.7	0.3	–	–	–	–	0.5	0.3	–	–	–	–	0.4	0.2	–	–	–	–
	Acceleration	Stroke [mm]						Stroke [mm]						Stroke [mm]					
X-Axis: **EZS6D** Z-Axis: **EZS3D**		50	100	150	200	250	300	50	100	150	200	250	300	50	100	150	200	250	300
	1.0 m/s^2	3.5	3.5	3.5	3.5	3.5	3.5	2.6	2.6	2.6	2.6	2.6	2.6	1.6	1.6	1.6	1.6	1.6	1.6
	2.5 m/s^2	3.1	3.1	3.1	3.1	3.1	3.1	2.3	2.3	2.3	2.3	2.3	2.3	1.4	1.4	1.4	1.4	1.4	1.4
	5.0 m/s^2	2.2	2.2	2.2	2.2	2.2	2.2	1.9	1.9	1.9	1.9	1.9	1.9	1.1	1.1	1.1	1.1	1.1	1.1
	Acceleration	Stroke [mm]						Stroke [mm]						Stroke [mm]					
X-Axis: **EZS6D** Z-Axis: **EZS4D**		50	100	150	200	250	300	50	100	150	200	250	300	50	100	150	200	250	300
	1.0 m/s^2	6.7	6.7	6.7	6.7	6.7	6.7	4.9	4.9	4.9	4.9	4.9	4.9	3.0	3.0	3.0	3.0	3.0	3.0
	2.5 m/s^2	5.9	5.9	5.9	5.9	5.9	5.9	4.3	4.3	4.3	4.3	4.3	4.3	2.6	2.6	2.6	2.6	2.6	2.6
	5.0 m/s^2	4.9	4.9	4.9	4.9	4.9	4.9	3.6	3.6	3.6	3.6	3.6	3.6	2.2	2.2	2.2	2.2	2.2	2.2

● Gn is the distance [mm] from the table to the center of gravity of the load.

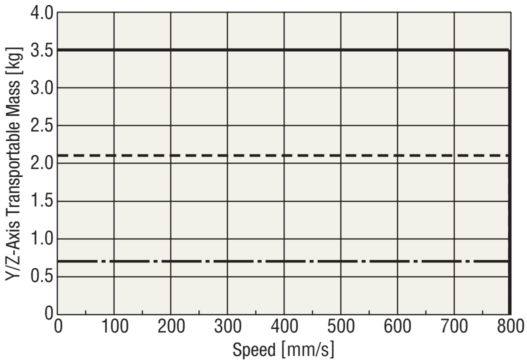
Speed – Transportable Mass Characteristics

◇X-Axis Speed (Common to the electromagnetic brake type)

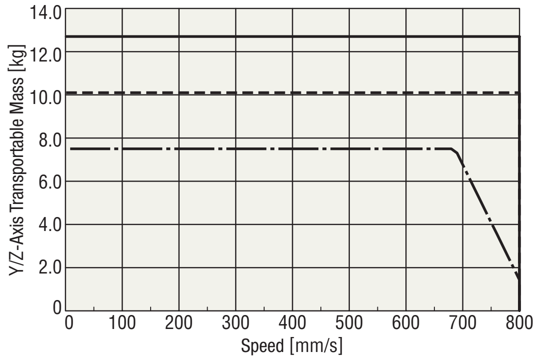
•Single-Phase 100-115 VAC/Single-Phase 200-230 VAC

Acceleration: —— $1.0\ m/s^2$ - - - $2.5\ m/s^2$ –·– $5.0\ m/s^2$

EZS4D□ (M) -A/EZS4D□ (M) -C



EZS6D□ (M) -A/EZS6D□ (M) -C



● A number indicating the stroke is specified in the box □ in the product name.

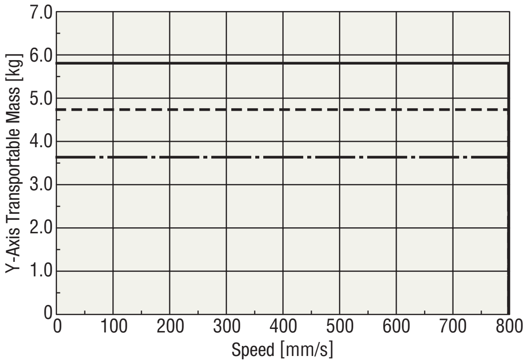
● For the X-axis, the maximum speed checked in the graph is limited by the stroke. Check the maximum speed of each stroke for the **EZSII** Series.

◇Y-Axis Speed (Common to the electromagnetic brake type)

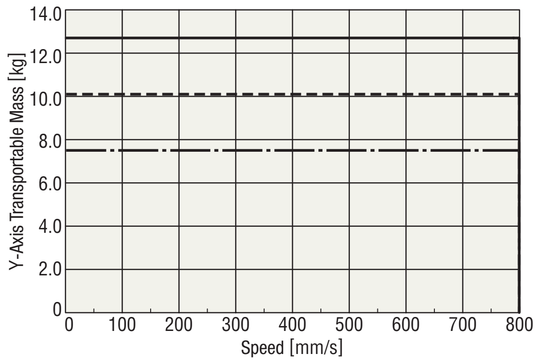
•Single-Phase 100-115 VAC/Single-Phase 200-230 VAC

Acceleration: —— $1.0\ m/s^2$ - - - $2.5\ m/s^2$ –·– $5.0\ m/s^2$

EZS3D□ (M) -A/EZS3D□ (M) -C



EZS4D□ (M) -A/EZS4D□ (M) -C

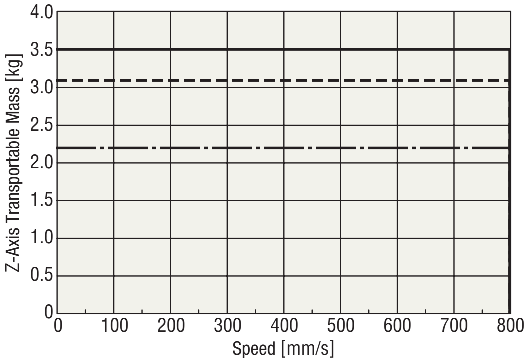


◇Z-Axis Speed (Common to the electromagnetic brake type)

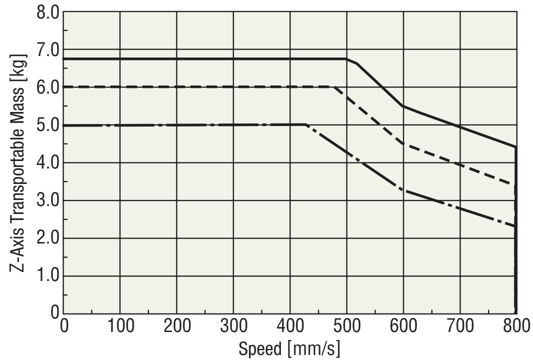
•Single-Phase 100-115 VAC/Single-Phase 200-230 VAC

Acceleration: —— $1.0\ m/s^2$ - - - $2.5\ m/s^2$ –·– $5.0\ m/s^2$

EZS3D□ (M) -A/EZS3D□ (M) -C



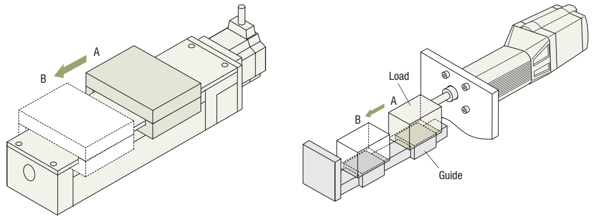
EZS4D□ (M) -A/EZS4D□ (M) -C



● A number indicating the stroke is specified in the box □ in the product name.

Selecting Motorized Linear Slides and Cylinders (Obtaining by calculations)

As illustrated below, the parameters listed below are required when selecting a motorized linear slide and motorized cylinder for transporting a load from A to B.



The required parameters are as follows:

- Mass of load (m) or thrust force (F)
- Positioning distance (L)
- Positioning time (T)
- Repetitive positioning accuracy
- Maximum stroke

Among the parameters above, the thrust force and positioning time can be calculated using the equations below.

Calculate the Thrust Force

① Calculate the required thrust force when accelerating the load

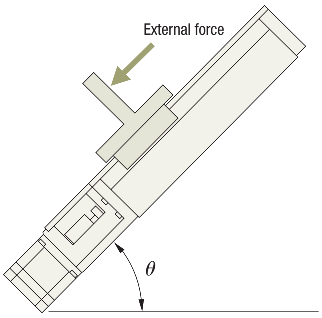
$$F_a = m\{a + g(\sin\theta + \mu \cdot \cos\theta)\}$$

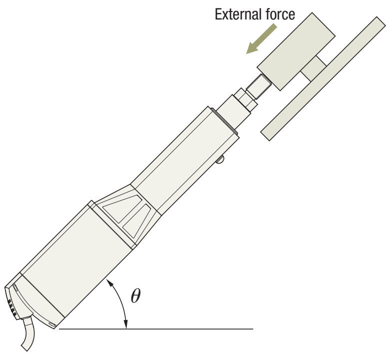
② Calculate the thrust force that allows for pushing and pulling

$$F = F_{max} - F_a$$

If the external force of the load is smaller than F, push and pull are possible.

F_{max}: Maximum thrust force of the motorized linear slides and cylinders [N]
F_a : Required thrust force during acceleration/deceleration operation [N]
F : Thrust force that allows for pushing or pulling of external force [N]
m : Mass of the load on the table and rod [kg]
a : Acceleration [m/s²]
g : Gravitational acceleration 9.807 [m/s²]
μ : Friction coefficient 0.01 (Friction coefficient of the guide supporting the load for motorized linear slides)
θ : Angle formed by the traveling direction and the horizontal plane [˚]





Calculate the Positioning Time

① Check the operating conditions

Check the following conditions:
Installation direction, load mass, positioning distance, starting speed, acceleration, operating speed

② Check whether the drive pattern is the triangular drive or trapezoidal drive from the above operating conditions.

For the triangular drive, calculate the maximum speed from the positioning distance, starting speed, acceleration and operating speed. If the calculated maximum speed is below the operating speed, the drive pattern will be a triangular drive. If the calculated maximum speed exceeds the operating speed, the drive pattern will be a trapezoidal drive.

$$V_{Rmax} = \sqrt{\frac{2 \cdot a_1 \cdot a_2 \cdot L}{a_1 + a_2} \cdot 10^3 + V_S^2}$$

$V_{Rmax} \leqq V_R \rightarrow$ Triangular Drive

$V_{Rmax} > V_R \rightarrow$ Trapezoidal Drive

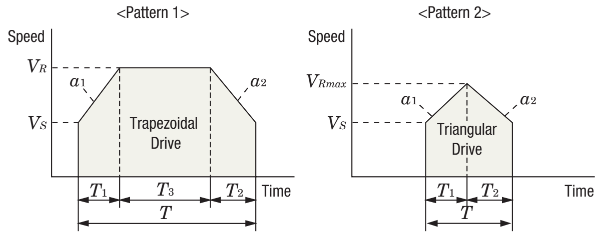
③ Calculate the positioning time

<Trapezoidal Drive>

$$T = T_1 + T_2 + T_3$$
$$= \frac{V_R - V_S}{a_1 \times 10^3} + \frac{V_R - V_S}{a_2 \times 10^3} + \frac{L}{V_R} - \frac{(a_1 + a_2) \times (V_R^2 - V_S^2)}{2 \times a_1 \times a_2 \times V_R \times 10^3}$$

<Triangular Drive>

$$T = T_1 + T_2$$
$$= \frac{V_{Rmax} - V_S}{a_1 \times 10^3} + \frac{V_{Rmax} - V_S}{a_2 \times 10^3}$$



V_{Rmax}: Calculated maximum speed of triangular drive [mm/s]
V_R : Operating speed [mm/s]
V_s : Starting speed [mm/s]
L : Positioning distance [mm]
a_1 : Acceleration [m/s²]
a_2 : Deceleration [m/s²]
T : Positioning time [s]
T_1 : Acceleration time [s]
T_2 : Deceleration time [s]
T_3 : Constant speed time [s]

The actual operating time is subject to a small margin of error, so use the calculation only as a reference.

Other conversion formulas are explained below.
The pulse speed and operating speed can be converted using the equation below. Keep the operating speed below the specified maximum speed.

$$\text{Pulse Speed [Hz]} = \frac{\text{Operating Speed [mm/s]}}{\text{Resolution [mm]}}$$

The number of operating pulses and traveling amount can be converted using the equation below.

$$\text{Number of operating pulses [pulses]} = \frac{\text{Traveling amount [mm]}}{\text{Resolution [mm]}}$$

The acceleration/deceleration rates and acceleration can be converted using the equation below.

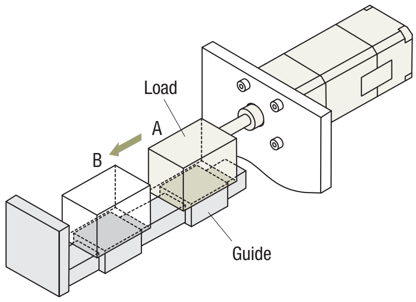
$$\text{Acceleration/deceleration rate [ms/kHz]} = \frac{\text{Resolution [mm]} \times 10^3}{\text{Acceleration [m/s}^2\text{]}}$$

The input methods for speed, traveling amount and acceleration will vary depending on the controller. Perform each calculation using the methods appropriate to the controller.

Compact Linear Actuators

Selecting the **DRL** Series

As illustrated below, the parameters listed below are required when selecting an actuator for transporting a load from A to B.



The required parameters are as follows:
- Mass of load (m) or thrust force (F)
- Positioning distance (L)
- Positioning time (T)

Among the parameters above, the thrust force and positioning time can be calculated using the equations below.

Calculate the Thrust Force

① Calculate the required thrust force when accelerating the load

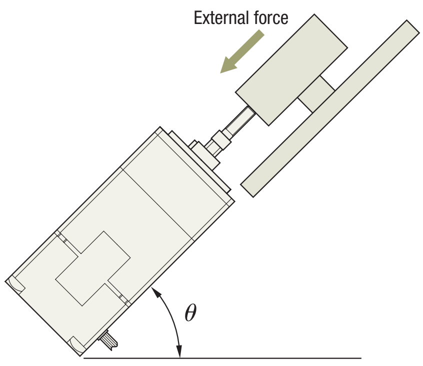
$$F_a = m\{a + g(\sin\theta + \mu \cdot \cos\theta)\}$$

② Calculate the thrust force that allows for pushing and pulling

$$F = F_{max} - F_a$$

If the external force of the load is smaller than F, push and pull are possible.

F_{max}: Maximum thrust force of the actuator [N]
F_a : Required thrust force during acceleration/deceleration operation [N]
F : Thrust force that allows for pushing or pulling of external force [N]
m : Load mass [kg]
a : Acceleration [m/s^2]
g : Gravitational acceleration 9.807 [m/s^2]
μ : Friction coefficient of the guide supporting the load 0.01
θ : Angle formed by the traveling direction and the horizontal plane [˚]

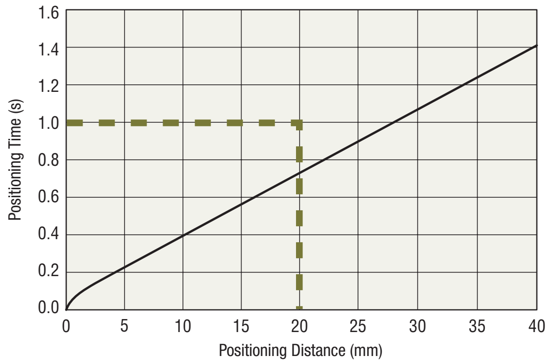


Calculate the Positioning Time

Check whether the actuator can perform the necessary positioning within the specified time. This can be done by obtaining a rough positioning time from the graph or by obtaining an accurate positioning time by calculation. Respective check procedures are explained below.
The actual operating time is subject to a small margin of error, so use the calculation only as a reference.

Obtaining from a Graph

Example: Perform positioning over a distance of 20 mm within 1.0 second using **DRL42PA2-04** (tentative selection). Transporting mass is 5 kg in vertical drive.
Check the graph of **DRL42**.



Based on the above graph, the load can be positioned over 20 mm within 1.0 second.

Obtaining by Calculations

① Check the operating conditions
Check the following conditions:
Installation direction, load mass, positioning distance, starting speed, acceleration, operating speed

② Check whether the drive pattern is the triangular drive or trapezoidal drive from the above operating conditions.
For the triangular drive, calculate the maximum speed from the positioning distance, starting speed, acceleration and operating speed. If the calculated maximum speed is below the operating speed, the drive pattern will be a triangular drive. If the calculated maximum speed exceeds the operating speed, the drive pattern will be a trapezoidal drive.

$$V_{Rmax} = \sqrt{\frac{2 \cdot a_1 \cdot a_2 \cdot L}{a_1 + a_2} \cdot 10^3 + V_S{}^2}$$

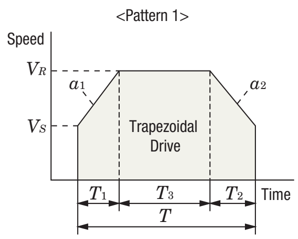
$V_{Rmax} \leqq V_R \rightarrow$ Triangular Drive
$V_{Rmax} > V_R \rightarrow$ Trapezoidal Drive

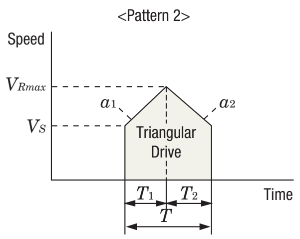
③ Calculate the positioning time
<Trapezoidal Drive>

$$T = T_1 + T_2 + T_3$$
$$= \frac{V_R - V_S}{a_1 \times 10^3} + \frac{V_R - V_S}{a_2 \times 10^3} + \frac{L}{V_R} - \frac{(a_1 + a_2) \times (V_R{}^2 - V_S{}^2)}{2 \times a_1 \times a_2 \times V_R \times 10^3}$$

<Triangular Drive>

$$T = T_1 + T_2$$
$$= \frac{V_{Rmax} - V_S}{a_1 \times 10^3} + \frac{V_{Rmax} - V_S}{a_2 \times 10^3}$$





V_{Rmax}: Calculated maximum speed of triangular drive [mm/s]
V_R : Operating speed [mm/s]
V_s : Starting speed [mm/s]
L : Positioning distance [mm]
a_1 : Acceleration [m/s^2]
a_2 : Deceleration [m/s^2]
T : Positioning time [s]
T_1 : Acceleration time [s]
T_2 : Deceleration time [s]
T_3 : Constant speed time [s]

Hollow Rotary Actuators

Selecting the DGII Series

This section describes the selection calculations for **DGII** Series.

Calculate the Required Torque

① Calculate the inertia (load inertia) of the load.
For the inertia of load, use 30 times or less of the actuator inertia as reference.

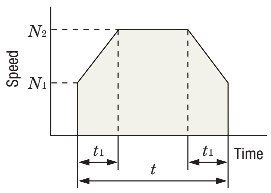
② Determine the positioning angle.

③ When there is no friction torque, check the positioning time from the Load Inertia – Positioning Time graph for the **DGII** Series. Refer to page E-153 for the Load Inertia – Positioning Time graph.

④ Determine the positioning time and acceleration/deceleration time.
Provided that:
The Positioning Time ≧ The Lowest Calculated Positioning Time Based on The Graph of Load Inertia – Positioning Time
where, Acceleration/Deceleration Time $t_1 \times 2 \leqq$ Positioning Time

⑤ Determine starting speed N_1, and calculate the operating speed N_2 using the formula below. Set N_1 to low-speed [0 to n r/min], and do not set it more than the required speed.

$$N_2 = \frac{\theta - 6N_1 t_1}{6(t - t_1)}$$



N_2 : Operating speed [r/min]
θ : Positioning angle [˚]
N_1 : Starting speed [r/min]
t : Positioning angle [˚]
t_1 : Acceleration (deceleration) time [s]

If $N_1 \leqq N_2 \leqq 200$ [r/min] is not correct using the above equation, return to step ④, and recheck the conditions.

⑥ Calculate the acceleration torque using the equation below.

$$T_a = (J_1 + J_L) \times \frac{\pi}{30} \times \frac{(N_2 - N_1)}{t_1}$$

T_a : Acceleration torque [N·m]
J_1 : Actuator inertia [kg·m²]
J_L : Total inertia [kg·m²]
N_2 : Operating speed [r/min]
N_1 : Stating speed [r/min]
t_1 : Acceleration (deceleration) time [s]

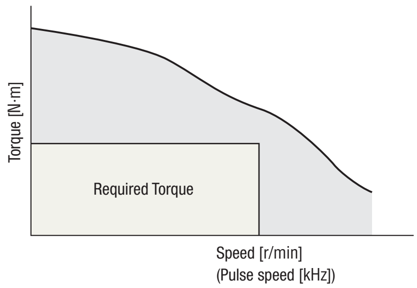
⑦ Calculate the required torque. The required torque is calculated by multiplying load torque of the frictional resistance plus the acceleration torque of the inertia by the safety factor.

$$T = (T_L + T_a)\, S_f$$

T : Required torque [N·m]
T_L : Load Torque [N·m]
T_a : Acceleration torque [N·m]
S_f : Safety factor

Keep the safety factor S_f at 1.5 or more.

⑧ Check whether the required torque T falls within the speed - torque characteristics. If the required torque is outside of the speed - torque characteristics, return to step ④, change the conditions and recalculate.



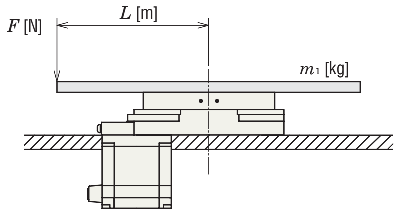
When switching conditions from speed to pulse speed, use the equation below.

$$f\,[\text{Hz}] = \frac{6N}{\theta s}$$

f : Pulse speed [Hz]
N : Speed [r/min]
θs : Output table step angle [˚/step]

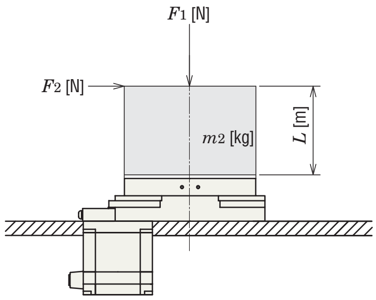
Calculate the Thrust Load and Moment Load

When there is a load on the output table as shown below, calculate the thrust load and moment load using the equation below, and check that they are within the specified values.



Thrust load [N] $F_s = F + m_1 \cdot g$
Moment Load [N·m] $M = F \cdot L$

g: Gravitational acceleration 9.807 [m/s²]



Thrust load [N] $F_s = F_1 + m_2 \cdot g$
Moment Load [N·m] $M = F_2(L + a)$

Product Name	a
DG60	0.01
DG85	0.02
DG130	0.03
DG200	0.04