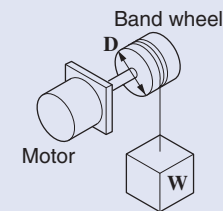


### Hoisting application



#### • SI units

$$T = \frac{1}{2} D \cdot W \text{ (N}\cdot\text{m)}$$

**D** : Diameter of drum (m)

**W** : Load (N)

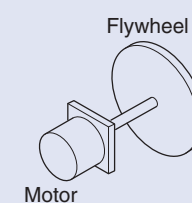
#### • Gravitational system of units

$$T = \frac{1}{2} D \cdot W \text{ (kgf}\cdot\text{m)}$$

**D** : Diameter of drum (m)

**W** : Load (kgf)

### Flywheel application



#### • SI units

$$T = \frac{J}{9.55 \times 10^4} \cdot \frac{N}{t} \text{ (N}\cdot\text{m)}$$

**N** : Rotating speed (min<sup>-1</sup>)

**J** : Inertia (kg·cm<sup>2</sup>)

**t** : Time (s)

#### • Gravitational system of units

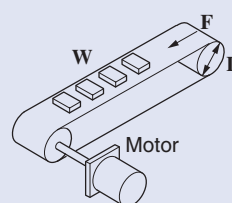
$$T = \frac{GD^2}{3750000} \cdot \frac{N}{t} \text{ (kgf}\cdot\text{m)}$$

**N** : Rotating speed (min<sup>-1</sup>)

**GD<sup>2</sup>** : Flywheel effect (kgf·cm<sup>2</sup>)

**t** : Time (s)

### Belt conveyor application



#### • SI units

$$T = \frac{1}{2} D (F + \mu Wg) \text{ (N}\cdot\text{m)}$$

**D** : Diameter of roll (m)

**W** : Mass of load (kg)

**g** : Gravitational acceleration (m/s<sup>2</sup>)

**μ** : Friction coefficient

**F** : External force (N)

#### • Gravitational system of units

$$T = \frac{1}{2} D (F + \mu Wg) \text{ (kgf}\cdot\text{m)}$$

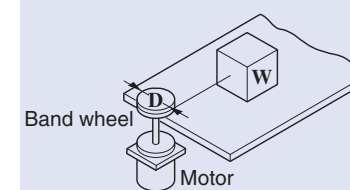
**D** : Diameter of roll (m)

**W** : Weight of load (kgf)

**μ** : Friction coefficient

**F** : External force (kgf)

### Horizontal travel on contact face



#### • SI units

$$T = \frac{1}{2} D \cdot \mu Wg \text{ (N}\cdot\text{m)}$$

**D** : Diameter of drum (m)

**W** : Mass (kg)

**μ** : Friction coefficient

#### • Gravitational system of units

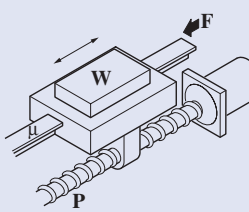
$$T = \frac{1}{2} D \cdot \mu W \text{ (kgf}\cdot\text{m)}$$

**D** : Diameter of drum (m)

**W** : Weight (kgf)

**μ** : Friction coefficient

### Ball screw drive



#### • SI units

$$T = \frac{1}{2\pi} P (F + \mu Wg) \text{ (N}\cdot\text{m)}$$

**F** : External force (N)

**W** : Mass of load (kg)

**μ** : Friction coefficient of sliding surfaces (approx. 0.05 to 0.2)

**g** : Gravitational acceleration (m/s<sup>2</sup>)

**P** : Lead of ball screw (m)

#### • Gravitational system of units

$$T = \frac{1}{2\pi} P (F + \mu Wg) \text{ (kgf}\cdot\text{m)}$$

**F** : External force (kgf)

**W** : Weight of load (kgf)

**μ** : Friction coefficient of sliding surfaces (approx. 0.05 to 0.2)

**P** : Lead of ball screw (m)

To describe the moment of inertia, **J** and **GD<sup>2</sup>** is used. **J** is generally called inertia and has the same value of physical moment of inertia in SI units. Unit is in **kg·m<sup>2</sup>**.

**GD<sup>2</sup>** (GD square) is called “flywheel effect” and generally used in industrial application with gravitational systems of units. Unit is in **kgf·m<sup>2</sup>** or **kgf·cm<sup>2</sup>**. A relation between **J** and **GD<sup>2</sup>** is described as:

$$J = GD^2 / 4$$

For the purpose of this document, both **J** for SI units and **GD<sup>2</sup>** for gravitational system of units are used. Unit of **J** should be **kg·m<sup>2</sup>** in dynamical significance, however, **kg·cm<sup>2</sup>** is used as well for convenience. Refer to pages A-52 and A-53 for calculation of **J** and **GD<sup>2</sup>** depending on the shape of the load.

### Checking of permissible inertia load

When the load inertia **J** connected to the gear head is large, frequent starting of the motor or electromagnetic brake generates a large torque. If this impact is excessive, it may damage the gear head and the motor. Since inertia varies with types of the load, the tables on pages A-52 and A-53 describe how to calculate inertia of different shape loads. The inertia of the load significantly affects life expectancy of gear and electromagnetic brake. When applying the braking force by using the electromagnetic brake or brake unit, do not exceed a permissible load inertia set for a specific model.

The permissible load inertia to a 3-phase motor is the inertia applied to the motor after it stops and then starts in the opposite direction.

- Find the load inertia to the motor shaft from the following formula. (SI units system)

$$J_M = J_G \times \frac{1}{i^2}$$

**J<sub>G</sub>** : Inertia of gear head output shaft (**kg·cm<sup>2</sup>**)

**J<sub>M</sub>** : Permissible inertia at motor shaft (**kg·cm<sup>2</sup>**)

**i** : Reduction ratio (e.g. 5 if the ratio is 1/5)

\* The formula also applies to **GD<sup>2</sup>** system.

- Find the permissible load inertia moment at gear head output shaft from the following formula.

When reduction ratio is 1/3 to 1/50, **J<sub>G</sub> = J<sub>M</sub> × i<sup>2</sup>**

When reduction ratio is 1/60 or larger, **J<sub>G</sub> = J<sub>M</sub> × 2500**

**J<sub>G</sub>** : Permissible load inertia moment at gear head output shaft (**kg·cm<sup>2</sup>**)

**J<sub>M</sub>** : Permissible inertia at motor shaft (**kg·cm<sup>2</sup>**)

**i** : Reduction ratio (e.g. 5 if the ratio is 1/5)

Permissible inertia (**J<sub>M</sub>**) at motor shaft varies with motors. To find the inertia for the motor in question, refer to tables on pages A50 and A51.

### Motor and load inertia

The equation of motion is described as below when the inertia load is driven by the motor.

$$T = J\alpha = J \cdot \frac{d\omega}{dt} = \frac{GD^2}{4} \cdot \frac{d\omega}{dt} = \frac{2\pi}{60} \cdot \frac{GD^2}{4} \cdot \frac{dn}{dt}$$

where,

**T** : Torque (**N·m**)

**J** : Moment of inertia (**kg·m<sup>2</sup>**)

**ω** : Angular speed (**rad/s**)

**t** : Time (**s**)

**n** : Rotational speed (**r/s**)

**GD<sup>2</sup>**: Flywheel effect (**GD<sup>2</sup> = 4J**)

**g** : Gravitational acceleration = 9.8 (**m/s<sup>2</sup>**)

**α** : Angular acceleration (**rad/s<sup>2</sup>**)

In the case of induction motor, torque generated at the starting varies depending on the speed. Therefore, an average acceleration torque is generally used, which is the averaged torque from the starting and the constant speed.

A necessary average acceleration torque **T<sub>A</sub>** to accelerate the load inertia of **J** (**kg·cm<sup>2</sup>**) (**GD<sup>2</sup>** (**kgf·cm<sup>2</sup>**)) up to a speed **n** (**min<sup>-1</sup>**) in time **t** (**s**) can be obtained by the following formula.

- SI units

$$T_A = \frac{J}{9.55 \times 10^4} \times \frac{N}{t} \quad (\text{N}\cdot\text{m})$$

- Gravitational system of units

$$T_A = \frac{GD^2}{3750000} \times \frac{N}{t} \quad (\text{kgf}\cdot\text{cm})$$

### Life of motor brake

Load inertia affects a lot to the life of the brake.

In the case of brake unit and variable speed motor, braking life is 2 million cycles, and in the case of a motor with electromagnetic brake, life is one million cycles.

### Life of brake in the motor

Life expectancy of motor varies depending on load fluctuation. To determine the life expectancy, a factor called service factor, as shown in the table below is used.

First choose the appropriate service factor according to the type of load and multiply the result by the required power to determine the design power.

### Motor self-inertia, average acceleration torque and permissible load inertia

- When using single-phase induction motor and brake unit
- When using single-phase variable speed induction motor and electric brake of speed controller
- When using 3-phase induction motor and brake unit

No. of phases	Size	Output (W)	Rotor inertia			Average acceleration torque			Permissible load inertia at motor shaft				
			J (kg-cm <sup>2</sup> )	J (oz-in <sup>2</sup> )	GD <sup>2</sup> (kgf-cm <sup>2</sup> )	(N-m)	(oz-in)	(kgf-cm)	J (kg-cm <sup>2</sup> )	J (oz-in <sup>2</sup> )	GD <sup>2</sup> (kgf-cm <sup>2</sup> )		
Single-phase Induction	42 mm sq. (1.65 inch sq.)	1	0.027	0.148	0.106	50 Hz 60 Hz	0.0127 0.0146	1.80 2.07	0.13 0.15	0.0125	0.068	0.05	
		3	0.027	0.148	0.106	50 Hz 60 Hz	0.0127 0.0146	1.80 2.07	0.13 0.15	0.0125	0.068	0.05	
	60 mm sq. (2.36 inch sq.)	3	0.103	0.563	0.412	50 Hz 60 Hz	0.0353 0.0333	5.00 4.72	0.36 0.34	0.125	0.683	0.50	
		6	0.163	0.891	0.650	50 Hz 60 Hz	0.0549 0.0529	7.77 7.49	0.56 0.54	0.125	0.683	0.50	
	70 mm sq. (2.76 inch sq.)	10	0.221	1.208	0.883	50 Hz 60 Hz	0.0755 0.0745	10.69 10.55	0.77 0.76	0.125	0.683	0.50	
		15	0.322	1.761	1.286	50 Hz 60 Hz	0.0971 0.0951	13.75 13.47	0.99 0.97	0.125	0.683	0.50	
	80 mm sq. (3.15 inch sq.)	15	0.438	2.395	1.751	50 Hz 60 Hz	0.126 0.118	17.84 16.71	1.28 1.20	0.138	0.755	0.55	
		25	0.578	3.160	2.311	50 Hz 60 Hz	0.199 0.201	28.18 28.46	2.03 2.05	0.138	0.755	0.55	
	90 mm sq. (3.54 inch sq.)	40	1.287	7.037	5.146	50 Hz 60 Hz	0.319 0.319	45.17 45.17	3.25 3.25	0.4	2.187	1.60	
		60	1.787	9.770	7.147	50 Hz 60 Hz	0.524 0.522	74.20 73.92	5.34 5.32	0.650	3.554	2.60	
	3-phase	80 mm sq. (3.15 inch sq.)	25	0.578	3.160	2.311	50 Hz 60 Hz	0.310 0.316	43.90 44.75	3.16 3.22	0.138	0.755	0.55
			40	1.287	7.037	5.146	50 Hz 60 Hz	0.667 0.513	94.46 72.65	6.80 5.23	0.4	2.187	1.60
90 mm sq. (3.54 inch sq.)		60	1.787	9.770	7.147	50 Hz 60 Hz	1.03 0.767	145.86 108.62	10.50 7.82	0.650	3.554	2.60	
		90	2.211	12.089	8.843	50 Hz 60 Hz	1.46 1.065	206.75 150.82	14.89 10.86	0.650	3.554	2.60	

- When using single-phase reversible motor and brake unit
- When using single-phase variable speed reversible motor and electric brake of speed controller

No. of phases	Size	Output (W)	Rotor inertia			Average acceleration torque			Permissible load inertia at motor shaft			
			J (kg-cm <sup>2</sup> )	J (oz-in <sup>2</sup> )	GD <sup>2</sup> (kgf-cm <sup>2</sup> )	(N-m)	(oz-in)	(kgf-cm)	J (kg-cm <sup>2</sup> )	J (oz-in <sup>2</sup> )	GD <sup>2</sup> (kgf-cm <sup>2</sup> )	
Single-phase Reversible	42 mm sq. (1.65 inch sq.)	1	0.029	0.159	0.114	50 Hz 60 Hz	0.0140 0.0153	1.98 2.17	0.14 0.16	0.0125	0.068	0.05
		4	0.113	0.618	0.452	50 Hz 60 Hz	0.0402 0.0392	5.69 5.55	0.41 0.40	0.125	0.683	0.50
	60 mm sq. (2.36 inch sq.)	6	0.173	0.946	0.691	50 Hz 60 Hz	0.0539 0.0549	7.63 7.77	0.55 0.56	0.125	0.683	0.50
		10	0.235	1.284	0.940	50 Hz 60 Hz	0.0676 0.0657	9.57 9.30	0.69 0.67	0.125	0.683	0.50
	70 mm sq. (2.76 inch sq.)	15	0.336	1.837	1.343	50 Hz 60 Hz	0.105 0.101	14.87 14.30	1.07 1.03	0.125	0.683	0.50
		20	0.460	2.515	1.839	50 Hz 60 Hz	0.146 0.141	20.68 19.97	1.49 1.44	0.138	0.755	0.55
	80 mm sq. (3.15 inch sq.)	25	0.600	3.280	2.399	50 Hz 60 Hz	0.218 0.205	30.87 29.03	2.22 2.09	0.138	0.755	0.55
		40	1.341	7.332	5.363	50 Hz 60 Hz	0.400 0.381	56.64 53.95	4.08 3.89	0.4	2.187	1.60
	90 mm sq. (3.54 inch sq.)	60	1.841	10.066	7.364	50 Hz 60 Hz	0.621 0.600	87.94 84.97	6.33 6.12	0.650	3.554	2.60
		90	2.265	12.384	9.060	50 Hz 60 Hz	0.796 0.736	112.72 104.23	8.12 7.51	0.650	3.554	2.60

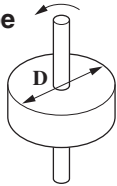
- When using single-phase electromagnetic brake motor
- When using single-phase variable speed reversible motor and electric brake of speed controller

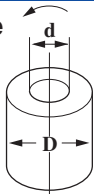
No. of phases	Size	Output (W)	Rotor inertia			Average acceleration torque			Permissible load inertia at motor shaft			
			J (kg-cm <sup>2</sup> )	J (oz-in <sup>2</sup> )	GD <sup>2</sup> (kgf-cm <sup>2</sup> )	(N-m)	(oz-in)	(kgf-cm)	J (kg-cm <sup>2</sup> )	J (oz-in <sup>2</sup> )	GD <sup>2</sup> (kgf-cm <sup>2</sup> )	
Single-phase Reversible	60 mm sq. (2.36 inch sq.)	6	0.201	1.099	0.805	50 Hz 60 Hz	0.0637 0.0647	9.02 9.16	0.65 0.66	0.080	0.437	0.32
		15	0.329	1.799	1.316	50 Hz 60 Hz	0.120 0.114	16.99 16.14	1.22 1.16	0.158	0.864	0.63
	80 mm sq. (3.15 inch sq.)	25	0.603	3.299	2.411	50 Hz 60 Hz	0.235 0.222	33.28 31.44	2.40 2.26	0.178	0.973	0.71
		40	1.362	7.447	5.446	50 Hz 60 Hz	0.439 0.420	62.17 59.48	4.48 4.28	0.735	4.019	2.94
	90 mm sq. (3.54 inch sq.)	60	1.862	10.180	7.447	50 Hz 60 Hz	0.639 0.615	90.49 87.09	6.52 6.27	0.875	4.784	3.50
		90	2.353	12.865	9.413	50 Hz 60 Hz	0.859 0.804	121.64 113.86	8.76 8.20	1	5.468	4.0
3-phase	80 mm sq. (3.15 inch sq.)	25	0.603	3.297	2.411	50 Hz 60 Hz	0.388 0.306	54.95 43.33	3.96 3.12	0.178	0.973	0.71
		40	1.362	7.447	5.446	50 Hz 60 Hz	0.667 0.513	94.46 72.65	6.80 5.23	0.735	4.019	2.94
	90 mm sq. (3.54 inch sq.)	60	1.862	10.180	7.447	50 Hz 60 Hz	1.031 0.767	146.00 108.62	10.51 7.82	0.875	4.784	3.50
		90	2.286	12.499	9.143	50 Hz 60 Hz	1.429 1.065	202.36 150.82	14.57 10.86	1	5.468	4.0

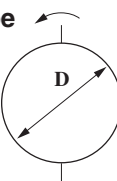
# Motor selection

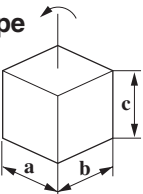
## Inertia

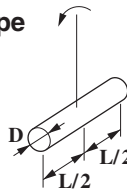
### How to calculate moment of inertia

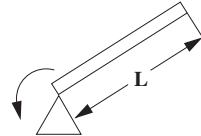
• Disk	J (Inertia calculation)	GD <sup>2</sup> (Flywheel effect calculation)
<b>• Shape</b> 	$J = \frac{1}{8} WD^2 \text{ (kg}\cdot\text{cm}^2\text{)}$ <p>W : Mass (kg) D : Outer diameter (cm)</p>	$GD^2 = \frac{1}{2} WD^2 \text{ (kgf}\cdot\text{cm}^2\text{)}$ <p>W : Weight (kgf) D : Outer diameter (cm)</p>

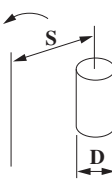
• Hollow circular cylinder	J (Inertia calculation)	GD <sup>2</sup> (Flywheel effect calculation)
<b>• Shape</b> 	$J = \frac{1}{8} W (D^2 + d^2) \text{ (kg}\cdot\text{cm}^2\text{)}$ <p>W : Mass (kg) D : Outer diameter (cm) d : Inner diameter (cm)</p>	$GD^2 = \frac{1}{2} W (D^2 + d^2) \text{ (kgf}\cdot\text{cm}^2\text{)}$ <p>W : Weight (kgf) D : Outer diameter (cm) d : Inner diameter (cm)</p>

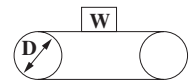
• Sphere	J (Inertia calculation)	GD <sup>2</sup> (Flywheel effect calculation)
<b>• Shape</b> 	$J = \frac{1}{8} WD^2 \text{ (kg}\cdot\text{cm}^2\text{)}$ <p>W : Mass (kg) D : Diameter (cm)</p>	$GD^2 = \frac{2}{5} WD^2 \text{ (kgf}\cdot\text{cm}^2\text{)}$ <p>W : Weight (kgf) D : Diameter (cm)</p>

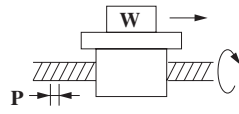
• Cube	J (Inertia calculation)	GD <sup>2</sup> (Flywheel effect calculation)
<b>• Shape</b> 	$J = \frac{1}{8} W (a^2 + b^2) \text{ (kg}\cdot\text{cm}^2\text{)}$ <p>W : Mass (kg) a,b : Length of side (cm)</p>	$GD^2 = \frac{1}{3} W (a^2 + b^2) \text{ (kgf}\cdot\text{cm}^2\text{)}$ <p>W : Weight (kgf) a,b : Length of side (cm)</p>

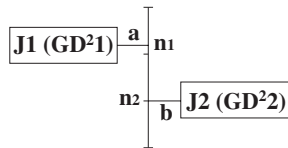
• Slender round bar	J (Inertia calculation)	GD <sup>2</sup> (Flywheel effect calculation)
<b>• Shape</b> 	$J = \frac{3D^2 + 4L^2}{48} \text{ (kg}\cdot\text{cm}^2\text{)}$ <p>W : Mass (kg) D : Outer diameter (cm) L : Length (cm)</p>	$GD^2 = \frac{3D^2 + 4L^2}{12} \text{ (kgf}\cdot\text{cm}^2\text{)}$ <p>W : Weight (kgf) D : Outer diameter (cm) L : Length (cm)</p>

• Straight bar	J (Inertia calculation)	GD <sup>2</sup> (Flywheel effect calculation)
<b>• Shape</b> 	$J = \frac{1}{3} WL^2 \text{ (kg}\cdot\text{cm}^2\text{)}$ <p>W : Mass (kg) L : Length (cm)</p>	$GD^2 = \frac{4}{3} WL^2 \text{ (kgf}\cdot\text{cm}^2\text{)}$ <p>W : Weight (kgf) L : Length (cm)</p>

• Discrete shaft	J (Inertia calculation)	GD <sup>2</sup> (Flywheel effect calculation)
<b>• Shape</b> 	$J = \frac{1}{8} WD^2 + WS^2 \text{ (kg}\cdot\text{cm}^2\text{)}$ <p>W : Mass (kg) D : Diameter (cm) S : Turning radius (cm)</p>	$GD^2 = \frac{1}{2} WD^2 + 4WS^2 \text{ (kgf}\cdot\text{cm}^2\text{)}$ <p>W : Weight (kgf) D : Diameter (cm) S : Turning radius (cm)</p>

• Horizontal linear motion	J (Inertia calculation)	GD <sup>2</sup> (Flywheel effect calculation)
<b>• Shape</b> 	$J = \frac{WD^2}{4} \text{ (kg}\cdot\text{cm}^2\text{)}$ <p>W : Mass on the conveyor (kg) D : Drum diameter (cm) * Inertia of drum not included</p>	$GD^2 = WD^2 \text{ (kgf}\cdot\text{cm}^2\text{)}$ <p>W : Weight on the conveyor (kgf) D : Drum diameter (cm) * Flywheel effect of drum not included</p>

• Ball screw	J (Inertia calculation)	GD <sup>2</sup> (Flywheel effect calculation)
<b>• Shape</b> 	$J = JA + \frac{W \cdot P^2}{4\pi^2} \text{ (kg}\cdot\text{cm}^2\text{)}$ <p>W : Mass (kg) P : Lead of feed screw (cm) JA : Inertia of feed screw (kg·cm<sup>2</sup>)</p>	$GD^2 = GD_A^2 + \frac{W \cdot P^2}{\pi^2} \text{ (kgf}\cdot\text{cm}^2\text{)}$ <p>W : Weight (kgf) P : Lead of feed screw (cm) GD<sub>A</sub><sup>2</sup> : Flywheel effect of feed screw (kgf·cm<sup>2</sup>)</p>

• Reducer	J (Inertia calculation)	GD <sup>2</sup> (Flywheel effect calculation)
<b>• Shape</b> 	<p>Equivalent all inertia on axis "a"</p> $J = J1 + \left(\frac{n2}{n1}\right)^2 J2 \text{ (kg}\cdot\text{cm}^2\text{)}$ <p>n1 : Speed of axis "a" (min<sup>-1</sup>) n2 : Speed of axis "b" (min<sup>-1</sup>) J1 : J of axis "a" (kg·cm<sup>2</sup>) J2 : J of axis "b" (kg·cm<sup>2</sup>)</p>	<p>Equivalent all flywheel effect on axis "a"</p> $GD^2 = GD^2_1 + \left(\frac{n2}{n1}\right)^2 GD^2_2 \text{ (kgf}\cdot\text{cm}^2\text{)}$ <p>n1 : Speed of axis "a" (min<sup>-1</sup>) n2 : Speed of axis "b" (min<sup>-1</sup>) GD<sup>2</sup><sub>1</sub> : GD<sup>2</sup> of axis "a" (kgf·cm<sup>2</sup>) GD<sup>2</sup><sub>2</sub> : GD<sup>2</sup> of axis "b" (kgf·cm<sup>2</sup>)</p>

Life expectancy of motor varies depending on load fluctuation. To determine the life expectancy, a factor called service factor, as shown in the table below is used. First choose the appropriate service factor according to the type of load and multiply the result by the required power to determine the design power.

### • Service factor

Type of load	Typical load	Service factor		
		5 hours/day	8 hours/day	24 hours/day
Constant	Belt conveyor, One-directional rotation	0.8	1.0	1.5
Light-impact	Start/Stop, Cam-drive	1.2	1.5	2.0
Medium-impact	Instant FWD/REV, Instant stop	1.5	2.0	2.5
Heavy-impact	Frequent medium-impact	2.5	3.0	3.5

### • Standard life expectancy

	Life (hours)		Life (hours)
Ball bearing	10,000 hours*	42 mm sq.	2,000 hours
Metal bearing	2,000 hours	Round shaft	10,000 hours*
Right-angle	5,000 hours	for C&B motor	5,000 hours

\* 5,000 hours when used on reversible motor

The standard life can be expected when the product is operated at service factor 1.0.

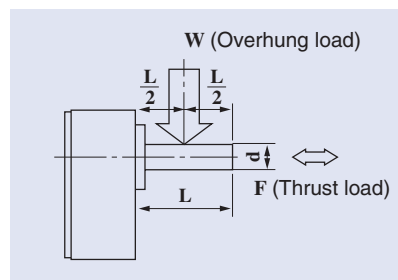
The life of a component during particular application is estimated by dividing the standard life expectancy by the service factor. If the service factor is 2.0, then the actual life will be one half the expected life.

## Overhung load and thrust load

The overhung load is defined as a load applied to the output shaft in the right-angle direction. This load is generated when the gear head is coupled to the machine using a chain, belt, etc., but not when the gear head is directly connected to the coupling. As shown in the right figure, the permissible value is determined based on the load applied to the  $L/2$  position of the output shaft. The thrust load is defined as a load applied to the output shaft in the axial direction. Because the overhung load and thrust load significantly affect the life of the bearing, take care not to allow the load during operation to exceed the permissible overhung load and thrust load shown in the table below.

### • Load

Size	Model	Permissible overhung load			Permissible thrust load		
		N	kgf	lb	N	kgf	lb
42 mm sq. (1.65 inch sq.)	M4GA□F	20	2	4.4	15	1.5	4.4
60 mm sq. (2.36 inch sq.)	MX6G□B(A)	98	10	22	29	3	6.6
	MX6G□M(A)	49	5	11			
70 mm sq. (2.76 inch sq.)	MX7G□B(A)	196	20	44	39	4	8.8
	MX7G□M(A)	98	10	22			
80 mm sq. (3.15 inch sq.)	MX8G□B	294	30	66	49	5	11
	MX8G□M	196	20	44			
90 mm sq. (3.54 inch sq.)	MX9G□B	392	40	88	98	10	22
	MX9G□M	294	30	66			
	MZ9G□B	588	60	132			
90 mm sq. (3.54 inch sq.) High torque	MR9G□B	784	80	176	147	15	33
	MP9G□B						
90 mm sq. (3.54 inch sq.) Right-angle	MX9G□R	392	40	88	98	10	22
	MZ9G□R	588	60	132	147	15	33



### 1. Speed suitable for use

Fig. 1 shows the typical torque curve, input dissipation curve and vibration curve.

In Fig. 1, the motor shows variations of 1100 to 1800 [min<sup>-1</sup>] according to the load. The speed most suitable for the load of the equipment is as follows:

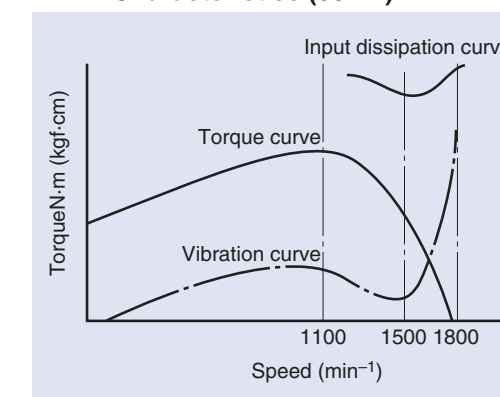
1200 to 1250 [min<sup>-1</sup>] for 50 Hz

1500 to 1550 [min<sup>-1</sup>] for 60 Hz

In this speed range, as can be seen from Fig. 1, the input dissipation becomes minimum, which means that the temperature rise of the motor is reduced accordingly.

As a result, the life of the motor, the insulation life, ball bearing grease life, etc. in particular, is prolonged. Also the vibration is minimized: in particular the gear noise caused when a gear head is used is reduced optimally. As described above, an optimum speed should be considered in selecting a motor.

Fig. 1 Example of Various Characteristics (60 Hz)



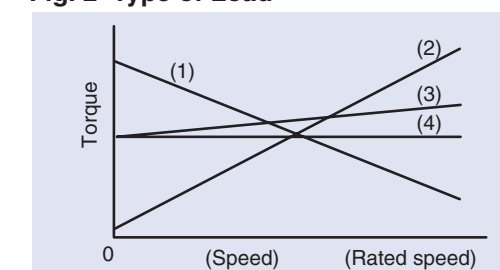
### 2. Examination of load of equipment

Examine the torque required for the load regarding the following three items.

- Minimum required torque at starting of the equipment
- Maximum load torque at load variations of the equipment
- Load torque at stable rotation

When the load torque is (1) to (4) in Fig. 2, the starting torque for (1), the stalling torque for (2) both the starting torque and stalling torque for (3) and (4) should be considered.

Fig. 2 Type of Load

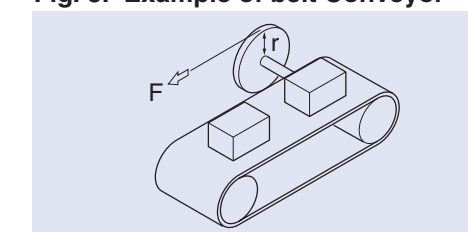


### 3. Calculation of required torque

• When the load of the equipment is (1), (3) or (4) in Fig. 2

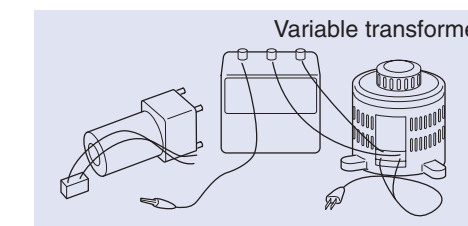
Calculate the approximate value of the required starting torque  $T_s$ . In Fig. 3 (Conveyor), for example, calculate the required force  $F$  from " $T = Fr$ ". Then select suitable motors from our catalog or the attached S-T data and check the minimum starting voltage, the minimum stable voltage and the speed in stable rotation. In accordance with the equipment load status calculated based on the above-mentioned examination, select a motor with the most suitable S-T curve.

Fig. 3. Example of belt Conveyor



### 4. Measurement of minimum starting voltage

Couple the motor to the load to be measured and connect a variable transformer and voltmeter as shown in the figure to the right. Increase the voltage continuously from 0 volt at the rate of 3 V/sec with this variable transformer and measure the when the rotating part of the equipment starts and gets ready for acceleration.



### 5. Measurement of minimum stable voltage

Drive the equipment in a stable state. Using the above-mentioned variable transformer, decrease the voltage gradually. Measure the voltage at the limit of the motor speed allowing the equipment to function, that is, when the equipment begins to stop.

## Calculation of motor capacity

### 6. Measurement of motor with gear head

When a motor alone is coupled to equipment, the speed is measured at output shaft section using a strobe light etc. In the case of a motor with a gear head, the speed is calculated from the following formula.

$$n = i \times n1$$

**n** : Motor speed (min<sup>-1</sup>)

**n1** : Speed of gear output shaft or pulley etc. attached to it

**i** : Reduction ratio of gear head (e.g. i = 30 for 1/30)

When measuring the speed of a gear output shaft having a large reduction ratio, do not measure the number of revolutions per minute, but measure the time taken for the gear output shaft to rotate 100 turns using a stopwatch after putting a mark on the shaft. Then calculate the number of revolutions per minute from the measured time.

### 7. Example of motor selection

Application : Driving of conveyor  
 Voltage : 100 V  
 Speed : 30 min<sup>-1</sup>  
 Working condition : Continuous  
 Frequency : 60 Hz  
 Select a motor that meet the above.

#### (1) Speed suitable for specifications

Because the required speed is 30 min<sup>-1</sup>, the gear ratio that realizes a rated motor speed (60 Hz area) of 1500 to 1550 min<sup>-1</sup> is 1500/30 to 1550/30 = 50 to 51.67. Therefore use a gear ratio of 1/50.

#### (2) Calculation of required torque

Measure the approximate load with a spring balance etc. Assume that it is **2.65 N·m (375.27 oz-in)**. After referring to our catalog, select **M81X25G4L** and install **MXBG50B** as a reduction gear.

#### (3) Actual measurement of minimum starting voltage, minimum stable voltage and speed

Assume that the following are obtained as a result of actual measurement.  
 Minimum starting voltage: 75 V  
 Minimum stable voltage: 55 V  
 Speed: 1700 min<sup>-1</sup>

#### (4) From speed-torque curve of 4-pole 25 W induction motor

**T<sub>s</sub>** : Starting torque **T<sub>s</sub> = 0.16 N·m (22.66 oz-in)**

**T<sub>m</sub>** : Stalling torque **T<sub>m</sub> = 0.25 N·m (35.4 oz-in)**

The torque is proportional to the square of the voltage and the following values are obtained.

#### (Minimum starting torque)

$$0.16 \times \left(\frac{75}{100}\right)^2 = 9 \times 10^{-2} \text{ N}\cdot\text{m} \text{ (12.75 oz-in)}$$

#### (Minimum required stalling torque)

$$0.25 \times \left(\frac{55}{100}\right)^2 = 7 \times 10^{-2} \text{ N}\cdot\text{m} \text{ (9.91 oz-in)}$$

#### (Torque at motor speed of 1700 min<sup>-1</sup>)

$$= 0.12 \text{ N}\cdot\text{m} \text{ (16.99 oz-in)}$$

From the above, it can be seen that this application is a constant torque load and that the 4-pole 25 W induction motor still has a more than sufficient capacity. In addition, as is evident from the S-T curve of the attached S-T data, **T<sub>s</sub>** and **T<sub>m</sub>** of the 4-pole 15 W induction motor are as follows:

$$\mathbf{T_s = 0.1 \text{ N}\cdot\text{m} \text{ (14.16 oz-in)}}$$

$$\mathbf{T_m = 0.15 \text{ N}\cdot\text{m} \text{ (21.24 oz-in)}}$$

Considering the voltage drop and variation when used for conveyors, **T<sub>s</sub>** and **T<sub>m</sub>** of the 4-pole 15 W induction motor at 90 V are assumed to be as follows:

$$\mathbf{T_s = 0.08 \text{ N}\cdot\text{m} \text{ (11.33 oz-in)}}$$

$$\mathbf{T_m = 0.12 \text{ N}\cdot\text{m} \text{ (16.99 oz-in)}}$$

When the voltage drop and variation or load variation is thought to be insignificant, the 4-pole 15 W induction motor and gear head MX7G50B can be used. When the voltage variation or load variation is significant, the 4-pole 25 W induction motor should be used.

### Domestic and overseas standards approved motors

For motors sold domestically or exported abroad, it is necessary to ensure the safety against "Fire, electric shock and injury" that meets the corresponding standards of each country. Among such standards are the Electrical Appliance and Material Safety Law in Japan, the UL standard in the North American market, the CE marking in the European market and the CCC marking in the Chinese market. We also provide products meeting these safety standards. The descriptions of these standards are shown below.

#### Electrical Appliance and Material Safety Law (domestic law in Japan)



This law is a domestic law in Japan intended to regulate the manufacture, sale, etc. of electrical appliances and to prevent the occurrence of fire, electric shock, injury, etc. attributable to electrical appliances by promoting self-activities of private enterprises for ensuring the safety of electrical appliances. Among the contents of the regulation are obligations of submission of manufacturing (export) business, conformance to technical standards and indication. Electrical appliances are classified into two groups: specific electrical appliances (equivalent to ko-type in the former law) and electrical appliances other than specific electrical appliances (otsu-type in the former law). On motors (electrical appliances other than specific electrical appliances) regulated by this law, a PSE mark is indicated and descriptions based on this law are shown.

#### UL (CSA) Standard (to be considered when exporting motors to North America)



This standard was established by the fire insurance company association in the United States of America. Like Japan, low voltage (115 V, 60 Hz) is used in this region, and measures against fire in particular are strongly required. Insulators used for UL-approved products are made of UL-approved incombustible materials. In addition, installation of an overheat protection device is required. In the case of motors with mounting surface dimensions of 70 mm sq., 80 mm sq. and 90 mm sq., an automatic-reset thermal protector is incorporated. In the case of motors with mounting surface dimensions of 60 mm sq., impedance protected motor design is used. The CSA standard is a necessary requirement for exporting to Canada. It is possible to put a c-UL mark on products inspected and approved by UL in accordance with the CSA standard in addition to the UL standard. Products bearing this c-UL mark are regarded as products conforming to CSA standard and therefore can be sold in Canada.

#### • UL standard on motor

- UL1004 (motor) : Provisions concerning motor construction and material
- UL2111 (thermal protection of motor) : Provisions concerning thermal protection of motor
- UL840 (insulation coordination of equipment) : Provisions concerning base items of motor insulation