Discontinued

Terminology

motor

Rating

There are limits of operation in terms of temperature rise to assure the motor performance. Rating is divided into continuous rating and short-time rating.
This defines not only the running limit against the output, but also limiting conditions such as voltage, frequency and rotational speed. These conditions are called as rated voltage, rated frequency and rated speed.

Continuous rating and short-time rating

A time rating is used to express the time during which the motor can normally output the rated power. Continuous rating indicates that the motor can provide the rated power during this period. The short-time rating indicates that the motor will reliably operate to produce the rated output for the relatively short time specified.

Output

Output represents a work which the motor can carry out in a unit time. This is determined by the rotational speed and the torque of the motor. The rated output of the motor, P0 is described in wattage

P0 (W) as;

- **SI units**
  $P0 = 0.1047 \times T \times N$
  T : Torque (N·m)
  N : Rotational speed (r/min)
- **Gravitational system of units**
  $P0 = 1.027 \times T \times N$
  T : Torque (kgf·m)
  N : Rotational speed (r/min)

Rated output

An optimum output performance which the motor can generate at the rated voltage and frequency. A rotational speed and torque with which the rated output is generated is called the rated speed and torque. In general, an output is referred to as the rated output.

Starting torque (see (1) in the figure)

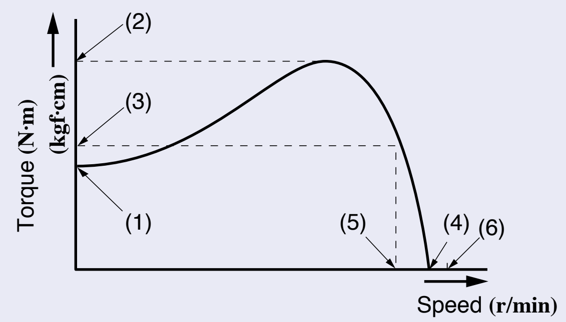
A torque which the motor generates at starting. The motor will not start if a larger load than this starting torque is applied to the motor.

Stalling torque (see (2) in the figure)

A maximum torque which the motor can generate at constant voltage and frequency. The motor will stall if a larger load than this torque is applied to the motor.

Rated toque (see (3) in the figure)

A torque of the motor generates the rated output continuously at rated voltage and frequency. This is usually referred to as a torque at the rated speed.



- Speed-torque characteristics
  (1) Starting torque
  (2) Stalling torque
  (3) Rated torque
  (4) No load speed
  (5) Rated speed
  (6) Synchronous speed

No load speed (see (4) in the figure)

Motor speed with no load applied. In the case of induction and reversible motor, this speed becomes a few percent lower (approx. 20 to 60 r/min) than a synchronous speed.

Rated rotational speed (see (5) in the figure)

Motor speed at which the motor generates the rated output. This is the most optimum speed.

Synchronous speed (see (6) in the figure)

An inherent speed determined by the number of poles of the motor and frequency of the power source.
This is described in the following formula.

$$Ns = \frac{120}{P} f \text{ (r/min)}$$

where, **Ns** : Synchronous speed (r/min)
f : Frequency (Hz)
P : Number of poles
120 : Constant

For example of 4-pole motor and power source frequency is 50 Hz, then,

$$Ns = \frac{120 \times 50}{4} = 1500 \text{ (r/min)}$$

Slippage

Slippage can be described in the following formula as one of the rotational speed.

$$S = \frac{Ns - N}{Ns} \text{ or } N = Ns(1 - S)$$

where, **Ns** : Synchronous speed (r/min)
N : Discretionary no load speed (r/min)

when an induction motor with 4-pole, 50 Hz runs with a slippage, S = 0.1, then,

$$N = Ns(1 - S) = 1500(1 - 0.1) = 1350 \text{ (r/min)}$$

Overrun

Revolutions that the motor makes from when the power source is turned off till the motor stops, and is described in the number of revolutions.

Fit tolerance

Fit tolerance symbol (JIS) is applied to dimensions of motor “Faucet face” and “Gear head” output shaft. The value of tolerance depends on the basic dimension. See the table right.

Classification of standard dimension		Shaft tolerance (unit: mm)
Over	Equal to or below	Shaft tolerance class: h7
–	3	0 –0.01
3	6	0 –0.012
6	10	0 –0.015
10	18	0 –0.018
18	30	0 –0.021
30	50	0 –0.025
50	80	0 –0.03
80	120	0 –0.035

Terminology

Gear head

Gear reduction ratio

A ratio of the gear head with which the gear head reduces the motor speed. Panasonic offers two groups of gear reduction ratio: one is for 3, 5, 7.5, 12.5, 15 ... and the other is 3.6, 6, 9, 15, 18 .... which are 1.2 times the previous group so that you can obtain approx. the same output speed for both 50 and 60 Hz. When it is necessary to fine adjust the speed smoothly use a variable speed motor and controller.

Maximum permissible torque

Maximum load torque which can be applied to the output shaft. This is determined by the mechanical strength such as material of gear head, gear teeth and bearing and the size of gear head as well as the reduction ratio.

Transmission efficiency

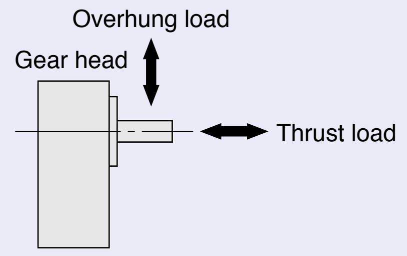
Efficiency with which motor torque is increased by the gear head, and described in %. This efficiency is determined by the bearing, friction of the gear tooth and resistance of lubricating oil. In general, this efficiency is approx. 90% per stage of the gear.
For example, 81 % for 2 stage configuration, and then decreases to 75 %, 70 %, 65 % as the number of stages increases. (In the case of metal gear head, this efficiency is approx. 85 % per stage of the gear.)

Service factor

Coefficient which is used to estimate the service life of the gear head.
This value is generally derived from experience and based on type of the load and operating conditions.

Overhung load

A vertical load applied to the output shaft of the gear head. This load is produced when the mated machine is being connected through a chain belt and the like but not produced if a coupling is used instead. Maximum value of the overhung load which is applicable to the shaft is called as “permissible overhung load”. This value varies depending on the type of gear head and the distance from the edge of the shaft. This value refers to the load such as belt tension.



Thrust load

An axial load applied to the output shaft of the gear head. Maximum value of the thrust load which is applicable to the shaft is called as “permissible thrust load”. This value varies depending on the type of the gear head.

Handling instructions

Temperature rise of motor

Heat generation and insulation

When a current runs through the motor, heat is generated as well. This heat generation is caused by an electrical loss and mechanical loss. An electrical loss consists of (1) copper loss which is generated in the charged part due to the resistance of the coil or conductor, and (2) iron loss which is generated in the iron portion of the motor due to the resistance of the iron portion while the magnetic flux crosses them. Mechanical loss is caused by friction loss of the bearing and brake lining.
Part of this heat generation accumulated to the motor and other is dissipated to outside of the motor through radiation, convection and conduction. The difference between the generated heat and dissipated heat makes the motor temperature rise, and is called heat run or temperature rise of the motor.
The hottest part on the motor is winding. Insulation used to protect the winding must be kept at a temperature below its maximum allowable temperature. Panasonic small geared motor is provided with the heat resistance class 120 (E) insulation when it is used in Japan, or class 130 (B) insulation when used outside Japan.
The class 120 (E) insulation will withstand temperature up to 120 ˚C.

· Type and temperature of insulation

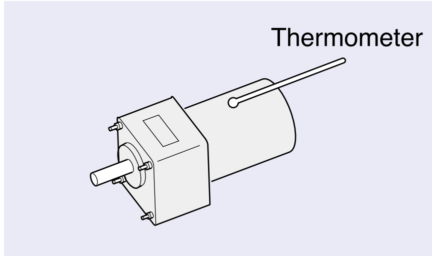
Type and temperature of insulation	Winding insulation material maximum allowable temperature	Winding temperature limit
90 (Y)	90 ˚C	–
105 (A)	105 ˚C	60 K (deg)
120 (E)	120 ˚C	75 K (deg)
130 (B)	130 ˚C	80 K (deg)
155 (F)	155 ˚C	100 K (deg)

When the heat resistance class 120 (E) insulation is used, the reduced maximum temperature limit on the motor frame 90 ˚C, at the 40 ˚C room temperature (max. temperature specified by JIS). This motor frame temperature will decrease to 70 ˚C at 20 ˚C room temperature. The maximum temperature limit is 50 K (deg) when measured on the frame.

Measurement of temperature rise

There are two methods to measure the temperature rise of the motor. One is to use a thermometer or thermocouple which is fixed on the center of the motor frame. The other method determines the temperature by measuring winding resistance as described below.

· Thermometer method



· Resistance method

Measure the winding resistance before and after the running, and then determine the temperature rise from the following formula.

$K\theta$: Temperature rise at the motor winding K (deg)

$$K\theta = \left(\frac{R2}{R1} - 1\right)(235 + t1) + (t1 - t2)$$

R1 : Winding resistance before running (W)
R2 : Winding resistance after running (W)
t1 : Room temperature before running (˚C)
t2 : Room temperature after running (˚C)
Note: This method applies only to copper winding.

Temperature rise of motor

Temperature rise of capacitor-run induction motor and 3-phase motor

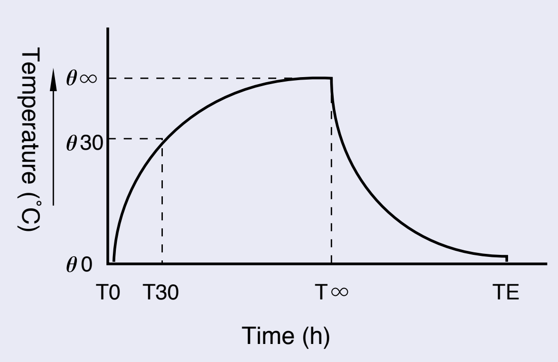
In the case of capacitor-run induction motor, temperature rise of the motor becomes highest at no load running. This means that the electrical loss becomes the maximum under no load condition and heat generation becomes larger than the loss at full load. This is because of the increase of current at primary and auxiliary winding due to the action of phase advance capacitor, and in addition to this, loss is generated to the armature by the reversed field due to the unbalance of the current.
In the case of 3-phase motor, heat generation at no load is much smaller than that of capacitor-run induction motor. However, temperature rise becomes larger as the load is increased due to the increase of input loss.

Temperature rise/cooling curve and running condition

Figure 1 shows the temperature rise and cooling curve indicating relation of time lapse and motor running.

T0 : Start running
T30 : 30 minutes after starting
T∞ : Temperature rise saturates
T∞h : Stop running
TE : Natural cooling to the same temperature as ambient temperature

• **Fig. 1 Temperature rise/cooling curve**



During the time between T0 and TE, temperature q varies as follows.

θ0 : Ambient temperature
θ30: Temperature after 30 minutes running
θ∞ : Saturated temperature
θ∞ – θ0 shows the temperature rise.

Typical Panasonic motors have the following time characteristics.

T∞ : 2.5 to 3 (**h**)
TE – T∞ : 3 to 4 (**h**)

(1) Induction motor
Induction motor is rated at continuous running, and is designed so as the temperature rise, θ∞ – θ0 of the winding is lower than 75 K (deg) (in case heat resistance class is 120 (E)) or 80 K (deg) (in case 130 (B)) international standard approved model). Therefore, the temperature does not rise beyond this when it is running continuously longer than T∞ hours.

(2) Reversible motor
Reversible motor is 30-minute rating, and is designed so as the temperature rise, θ30 – θ0 of the winding after minute running is lower than 75 K (deg). (in case heat resistance class is 120 (E)) or 80 K (deg) (in case 130 (B)) international standard approved model.
Therefore, the motor may be burned out if it is used longer than 30 minutes continuously.

(3) Special conditions
Normal working conditions for these motors are –10 ˚C to +40 ˚C, and under 85 % RH. Special attention is required when using these motors under the following conditions A to E.

A. Under –10 ˚C environment
Output torque of the motor might be reduced since the viscosity of the grease of the gear head or motor bearing increases. Condensation may occur when the motor is subjected to a sudden drop in the temperature. If it occurs, rust will be generated and have an adverse effect to the service life.

B. Over +40˚C environment
Motor winding temperature gets very hot, and will result in deterioration of insulation and may result in burnout. Also, lubricating grease of the bearing may leak out to shorten the life of the bearing, and may result in the motor lock, and then result in burnout.

C. Over 85% RH environment
This may deteriorate the winding insulation. When the products are transported by air cargo or vessel and are subjected to high temperature and humidity, pack the products in air-tight and take a necessary treatment such as insertion of drying agents.

D. Poor-ventilation environment
Same effect may appear as the above (B) condition.
If the motor is enclosed, environmental temperature gets very high, and then may shorten the service life drastically. Make a good ventilation environment by installing a vent so that the environmental temperature is kept 40˚C or less.

E. Other unfavorable environment
Operation under these conditions must be avoided:
Place where the product is subjected to; dust, water/oil/coolant splash, explosive/flammable or corrosive gas (H_2S, SO_2, NO_2, Cl_2, etc.).

(4) In the case of international standard approved model
• When using a pinion shaft motor, use it with the gear head attached.
• When using a round shaft motor, provide a means so that the heat dissipates over the machine and equipment.
<Reference>
The table below shows size and material of heat sinks.

Motor size (model No.)		Size	Material
60 mm sq. (2.36 inch sq.)	(M6.....)	100 x 100 x 5 mm (3.94 x 3.94 x 0.20 inch)	Aluminum
70 mm sq. (2.76 inch sq.)	(M7.....)	120 x 120 x 5 mm (4.72 x 4.72 x 0.20 inch)	Aluminum
80 mm sq. (3.15 inch sq.)	(M8.....)	135 x 135 x 5 mm (5.31 x 5.31 x 0.20 inch)	Aluminum
90 mm sq. (3.54 inch sq.)	(M9*X.....)	165 x 165 x 5 mm (6.50 x 6.50 x 0.20 inch)	Aluminum
	(M9*Z.....)	195 x 195 x 5 mm (7.68 x 7.68 x 0.20 inch)	Aluminum

* The temperature of the winding should be 80 K (deg) or below when measured using resistance method after rated operation with heat sink attached.

Operation environment standard

(1) Reference
Temperature rise of winding should be limited to:
• 75 K (deg): Japanese version
• 80 K (deg): International standard approved version

(2) Measurement method
Run the motor in the worst operation pattern (in terms of temperature rise) and measure the highest motor frame temperature with a thermometer. The reading should be 90 ˚C or below when the ambient temperature is 40 ˚C.
Of course, ambient temperature will become higher if ventilation is not enough. In that case, measure the temperature at a point close to the motor.

Handling instructions

Temperature rise of motor

Temperature rise of reversible motor

Reversible motor is 30-minute rating when it is running alone. However, when it is used with the gear head, continuous running time will be extended thanks to heat radiation effect of the gear head. The table below shows which motor can operate continuously under such condition. When these motors are operated intermittently, the temperature rise will be saturated at certain value depending on the cycle of intermittent running.

・Continuous running of reversible motor

Size	Motor model No.	Continuous running with gear head	
		50 Hz	60 Hz
60 mm sq. (2.36 inch sq.)	M6RX4G4L	○	○
	M6RX6G4L	○	○
70 mm sq. (2.76 inch sq.)	M7RX10G4L	○	×
	M7RX15G4L	○	×
80 mm sq. (3.15 inch sq.)	M8RX20G4L	○	×
	M8RX25G4L	○	×
90 mm sq. (3.54 inch sq.)	M9RX40G4L	×	×
	M9RX60G4L	×	×
	M9RX90G4L	×	×

*○: Continuous running is possible　×: Continuous running is not possible

・Fig. 2 Usable range of reversible motor (intermittent)

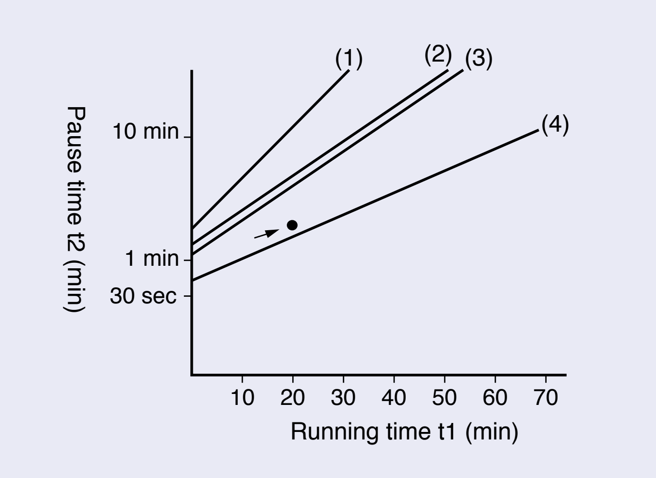


Figure 2 shows the limit curve for continuous intermittent running for the reversible motors. Horizontal axis shows the running time t1 and vertical axis shows the pause time t2. The motor can be operated for a continuous intermittent running in the range of these lines.
In this figure, each line represents as below:
(1) Motor alone running at 60 Hz
(2) Motor alone running at 50 Hz
(3) Motor with gear head running at 60 Hz
(4) Motor with gear head running at 50 Hz

For example, if you want to make continuous intermittent running of the motor alone with a cycle of t1 = 20 min and t2 = 2 min, the line under the crossing point of t1 = 20 and t2 = 2 is line (4). Hence, you can only make a continuous intermittent running with motor with gear head at 50 Hz under these conditions. If you want to run the motor alone and at 60 Hz for 20 minutes, you need to have the following pause time.
(1) 10.1 minutes for the motor alone at 60 Hz
(2) 4.6 minutes for the motor alone at 50 Hz
(3) 3.8 minutes for the motor with gear head at 60 Hz

If you fix the pause time to 2 minutes and want to see how long you can run the motor continuously, find the crossing point of t1 and each line while t2 = 2 (constant), and each value becomes as below.
(1) 2.5 minutes of running time for the motor alone at 60 Hz
(2) 7 minutes of running time for the motor alone at 50 Hz
(3) 10 minutes of running time for the motor with gear head at 60 Hz
(4) 27.5 minutes of running time for the motor with gear head at 50 Hz

Impedance protect

Impedance protect is a means to prevent burning of a motor if it becomes failure i.e. in lock state, even if it is not provided with a safety device such as thermal protector. This is because the amount of current will not increase during locking state. It is blocked by the impedance produced by thin wire coil. Without this impedance protect, the motor temperature rises to 75 K (deg) or more during locking state and winding coil may be burned.
Panasonic geared motors of 4-pole, 6 W or smaller are provided with the impedance protect and conform to UL standard UL2111.
The impedance protect should be activated only when its burning protection feature is absolutely necessary. This implies that the motor must be used under the maximum permissible temperature. The expected motor life decreases by the factor if 1/2, 1/4 and so on as the temperature increases in step of 8 ˚C beyond the maximum permissible temperature.
* UL standard specifies the impedance protect value to 125 K (deg) at winding for Japanese version and 135 K (deg) for international version.

Thermal protector

The thermal protector is a safety device which automatically turns off the motor current as the motor winding temperature exceeds the preset temperature and turns on the current again as the temperature drops below the preset temperature.

・Fig. 3 Operation of thermal protector

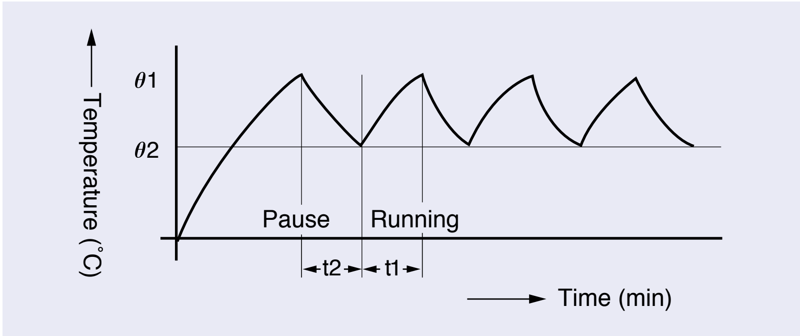


Figure 3 illustrates on/off cycle of the thermal protector. On Panasonic motors, threshold temperature is set as shown below.

Motors conforming to international standards
θ1 (open)　130 ˚C ±　5 ˚C
θ2 (closed)　90 ˚C ± 15 ˚C
Japanese version, variable speed 90 W motors
θ1 (open)　120 ˚C ±　5 ˚C
θ2 (closed)　77 ˚C ± 15 ˚C

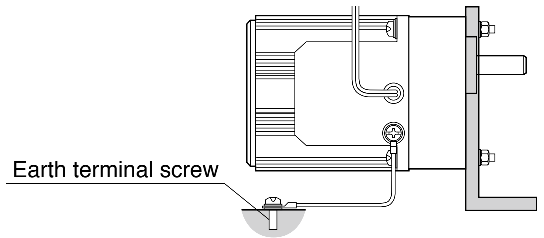
These settings and time t1 and t2 vary depending on operating environment and loads.
For compact geared motor with thermal protector, refer to the separate Panasonic international motor catalog.

Wiring to motor

• Wiring work should be performed by qualified electrician.
• Turn off power and remain off until the wiring is completed.

Grounding (earth ground)

• Positively connect the equipment to the ground.
• Use only the grounding screw provided on the product. Tighten the screw with a toque of 1.2 N·m to 1.5 N·m (recommended).
• For grounding a motor with seal connector, connect the connector internal ground terminal to the earth.
• Use screw, spring washer and flat washer made of stainless steel or copper alloy in the grounding circuit.
• Use round terminal as grounding terminal. Do not use U-shaped terminal.



<Precautions>
Round ground terminal and grounding leadwire, and grounding screw, spring washer and flat washer on the ground return circuit should be prepared by the customer. Earth grounding leadwire should be of size ø1.6 mm (2 mm^2) or more.

Leadwire

Don't forcibly bend, pull or pinch motor leadwires.

Connection

• Connections or joints of motor leadwires, power cable and capacitor should be made using soldering, connector or crimping terminal, whichever suitable, and should be covered with appropriate insulating material.
• Clamp the motor leadwires on the equipment at stable area so that the leadwires are kept stress free.

Connecting to the terminal block with seal connector

Tightening torque of the screw used for the terminal box is shown in the table below.

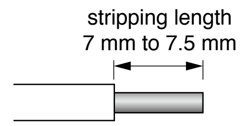
Place of use	Tightening torque (N·m)
Screw for cap	3.75 to 4.0
Terminal block cover mounting screw	0.78 to 0.98
Clamping screw	0.39 to 0.49
Earth terminal screw	1.2 to 1.5

AWG-JIS Comparison table

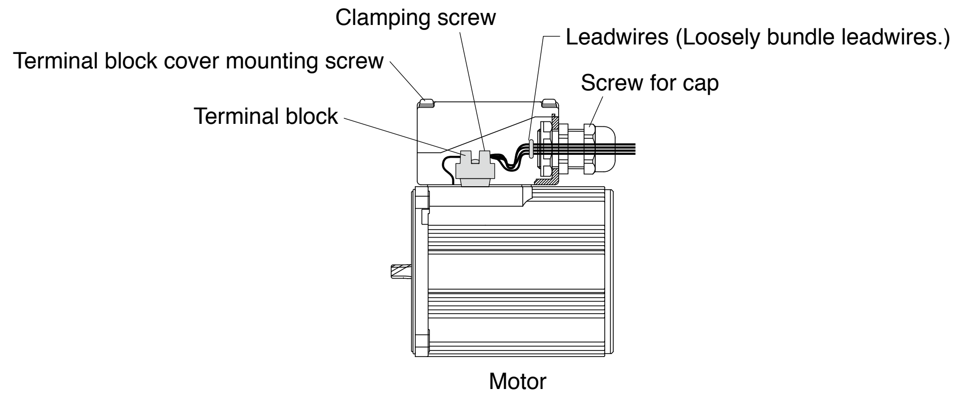
AWG	Cross sectional area (mm^2)	JIS
AWG24	0.205	0.2 sq
AWG22	0.326	0.3 sq
AWG20	0.518	0.5 sq
AWG18	0.823	0.75 sq
AWG16	1.31	1.25 sq
AWG14	2.08	2 sq

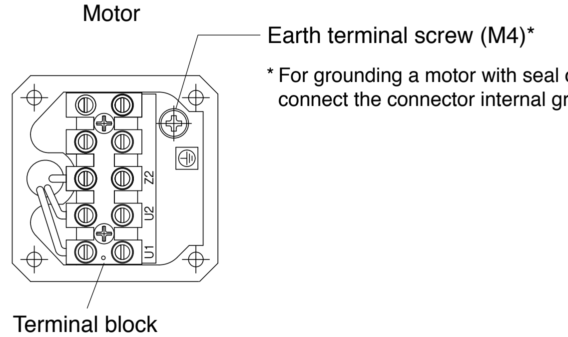
The applicable wires to the terminal block are as follows.

Applicable cabtire cable outer diameter		ø8 mm to ø12 mm
Core wire diameter	Stranded wire	AWG14 to AWG20
	Single wire	AWG14 to AWG20
Earth wire		AWG14 or more
stripping length		7 mm to 7.5 mm



• Earth grounding leadwire should be of size ø1.6 mm (2 mm^2) or more.
• Don't squeeze the insulation of the lead wire with the clamp.
• The lead wire should not have fraying conductors.
• Don't solder conductor of the lead wire.
• Clamp the motor leadwires on the equipment at stable area so that the leadwires are kept stress free.





* For grounding a motor with seal connector, connect the connector internal ground terminal to the earth.

Handling instructions

Safety Precautions

The following explanations are for things that must be observed in order to prevent harm to people and damage to property.

• Misuses that could result in harm or damage are shown as follows, classified according to the degree of potential harm or damage.

⚠ **Danger**	Indicates great possibility of death or serious injury.
⚠ **Caution**	Indicates the possibility of injury or property damage.

• The following indications show things that must be observed.

⃠	Indicates something that must not be done.
❗	Indicates something that must be done.

⚠ Danger

⃠	**Don't expose the equipment to water, corrosive environment or flammable gas or close to flammable material.**	Will cause fire.
	Don't place a flammable object close to the speed controller and motor.	
	Don't use the product in a place subject to excessive vibration or shock.	Will cause electric shock, personal injury or fire.
	Don't use cables soaked in water or oil.	Will cause electric shock, malfunction or damage.
	Don't attempt to carry out wiring or manual operation with wet hand.	Will cause electric shock, personal injury or fire.
	Don't damage cables or subject cables to excessive stress such as strong pressure, heavy object and clamping load.	Will cause electric shock, malfunction or damage.
	Don't make soldering joint on a round pin of the speed controller.	Will cause fire.
	Don't drive the 380/400 VAC 3-phase motor from the inverter.	Will cause electric shock, personal injury, fire, malfunction or damage.
	Don't touch potentially hot motor casing.	Will cause burn injury.
	Never touch rotating member of the motor.	Will cause personal injury.
	Never remove the speed setting knob from the controller.	Will cause electric shock or personal injury such as skin burn.

⚠ Danger

❗	**Installation area should be free from excessive dust, and from splashing water and oil.**	Failure to heed this precaution will result in electric shock, fire, malfunction or damage.
	Install the unit to a nonflammable construction (e.g. metal).	Installation on a flammable material may cause fire.
	Wiring work should be done by a qualified electrician.	Wiring work done by an inexperienced person will cause electric shock.
	Correctly run and arrange wiring.	Wrong wiring will cause personal injury or electric shock.
	After correctly connecting cables, insulate the live parts with insulator.	Incorrect wiring will result in short circuit, electric shock, fire or malfunction.
	Ground the motor to the earth.	Floating ground circuit will cause electric shock.
	Correctly run wirings to the external speed setter and tacho-generator.	Incorrect wiring will result in short circuit, electric shock, personal injury, etc.
	Install the product in the control board to make its terminal block inaccessible.	Failure to heed this requirement will result in electric shock, personal injury, fire, malfunction or damage.
	Securely install and fix the equipment to prevent bodily injury or fire in case of earthquake.	Failure to heed these requirements will result in electric shock, personal injury or fire, malfunction or damage.
	Provide emergency stop circuit externally for instantaneous interruption of operation and power supply.	
	Install overcurrent protection device, ground-fault circuit interrupter, overtemperature protecting device, and emergency stop device.	Failure to heed these requirements will result in electric shock, personal injury or fire.
	After an earthquake, first verify safety.	
	Turn off power upon power interruption or activation of overtemperature protecting device.	Unpredictable restarting will cause personal injury.
	Before transferring, wiring or checking, disconnect the power source from the motor system for safe isolation.	Energized circuit will cause electric shock.

Handling instructions

Safety Precautions

⚠ Caution

🚫	Don't move the motor by holding cables or motor shaft.	Failure to heed these precautions cause bodily injury.
	Don't drop or cause topple over of something during transportation or installation.	Failure to heed this instruction will result in personal injury or malfunction.
	Don't step on the product. Don't place heavy object on the product.	Failure to heed this instruction will result in electric shock, personal injury, malfunction or damage.
	Don't use the equipment under direct sunshine.	Failure to heed these instructions will cause personal injury or fire.
	Don't use the equipment in highly intensive electric field.	
	Don't use the equipment in an environment where electro-static voltage potentials may be produced.	Induced malfunction will cause personal injury.
	Don't block the motor air opening by an object.	Failure to heed this instruction will result in electric shock or fire.
	Don't apply excessive shock to the product.	Excessive shock will cause failure.
	Don't apply excessive shock to the motor shaft.	
	Don't turn off and on power so frequently.	Failure to heed this instruction will result in personal injury, fire, malfunction or damage.
	Don't put the machine into unstable operation.	Failure to heed these precautions cause bodily injury.
	Don't energize the C&B motor clutch and brake at the same time.	Failure to heed this instruction will result in fire, electric shock, or malfunction.
	Don't use smaller variable transformer or transformer.	
	Don't pull cables with an excessive force.	Failure to heed this instruction will result in electric shock, personal injury or fire.
	Don't lock the motor shaft while the motor is running.	Locked motor will cause fire, electric shock, or malfunction.
	Once power failure occurs, don't come close to the machine that will unexpectedly start upon recovery of the power. Provide secure mechanism so that the restarting of the machine will not cause personal injury.	Failure to heed these precautions cause bodily injury.
	Don't operate the product outside its ratings stated on the nameplate and instruction manual.	Failure to heed this instruction will result in personal injury, electric shock, fire, malfunction or damage.
	Never attempt to perform modification, disassembly or repair.	Failure to heed this instruction will result in fire, electric shock or personal injury.

⚠ Caution

❗	Perform installation by taking into consideration the mass of the body and rated output of the product.	Incorrect installation or mounting will cause personal injury or malfunction.
	Exactly follow the installing method and direction specified.	
	Don't place any obstacle object around the motor and peripheral, which blocks air passage.	Temperature rise will cause burn injury or fire.
	Adjust the motor and speed controller ambient environmental condition to match their operating temperature and humidity.	Incorrect installation or mounting will cause personal injury or malfunction.
	Connect a ground-fault interrupter, circuit breaker and relay to the brake control relay in series so that they are turned off upon emergency stop.	Missing of one of these devices will cause malfunction.
	Provide protection device against slipage of brake or gear head, or grease leakage from gear head.	Lack of protection will cause personal injury, damage or pollution.
	Always install a safety system that will back up the braking system failing to operate due to power interruption or voltage drop.	Lack of protection will cause personal injury, damage or malfunction.
	Use the speed controller in combination with the specified motor.	Incorrect combination will cause fire.
	Level of input voltage to a peripheral block should correspond to the motor rated voltage.	Operation from a voltage outside the rated voltage will cause electric shock, personal injury or fire.
	Test-run the securely fixed motor without load to verify normal operation, and then connect it to the mechanical system.	Operation with a wrong model or wrong wiring connection will result in personal injury.
	Maintenance must be performed by an experienced personnel.	Wrong wiring will cause personal injury or electric shock.
	Always keep power disconnected when the power is not necessary for a long time.	Improper operation will cause personal injury.
	Scraps must be treated as industrial waste.	

Operating instruction

- **Before running the motor**

  Check the following points:
  - Correct wiring to the power source?
  - Secure grounding to earth?
  - Appropriate fuse and circuit breaker?
  - No loose connection to the machine? No loose tightening bolts?
  - No oil or grease leakage nor blot?

- **Trial running**

  Make a trial run:

  (1) Without a load, turn on the motor and gear head to verify the rotational direction and speed, and check for abnormal state, i.e. vibration, noise, etc. Install the motor and gear head on the machine.

Do	**Check rotating direction**	Unexpected operation or movement will cause malfunction or personal injury.

  (2) Turn on power and verify that the motor runs smoothly and the bearing and gear head produce no abnormal sounds.

- **While motor is running**

  Check the load:
  - Measure the current flow rate and adjust the load so that the current value is well below the rating described on the nameplate.
  - When the reduction ratio of the gear head is 1/50 or more, the torque will exceed the permissible shaft torque even if the measured current value is lower than nameplate rating. If this is the case, decrease the load.

  Check the temperature rise of the motor:
  - Temperature rise will saturate by 3 hours after starting the motor. For the reversible motor and single-phase induction motor with electromagnetic brake, observe the time rating of 30 minutes.
  - Keep the frame temperature 90 ˚C or below when the ambient temperature is 40 ˚C.

- **At power failure:**

  Immediately turn off main power switch.
  - Unexpected accident may occur when the power recovers while the switch is in on position; or the motor may not start if the load is too heavy and the winding may burn.

- **While the motor is running:**
  - Do not touch the motor since it gets very hot. (Or it may result in burn injury.)
  - Turn off the motor as the system shows unexpected behavior. (Consult the local agent as necessary.)

- **Other precautions:**

  Check the starting voltage:

  With the geared motor installed on the machine, check the starting voltage of the motor using a variable transformer and voltmeter. The voltage should be lower than the value shown below.

  (1) Reversible motor: 70 % of the rated voltage

  (2) Induction motor: 80 % of the rated voltage
  - The machine may not start if the voltage fluctuates. The machine may not start because of change in the static friction torque due to the aging or temperature, or fluctuation of the motor.

Inspection and maintenance

Periodically perform check and maintenance to assure safe and reliable operation.

- **Practical considerations for maintenance**
  - To secure safety during maintenance operation, turning off/on of power supply must be done by the personnel who is responsible for the current maintenance work.
  - Do not touch the motor while it is still running or immediately after it stops. (Motor is hot.)
  - Before starting the megger testing of the motor (to measure the insulation resistance), completely disconnect it from associated devices and components.
    Otherwise, the megger tester will damage the devices under test.

- **Daily check**
  - Perform the daily check to prevent potential problems.
  - Perform appropriate corrections upon finding any failure or defective.

Check item	Checking method	Description
Change in voltage	Voltmeter	Rated voltage ±2 % to 3 %. Although the specification assures normal operation within ±10 % deviation, the motor performance and life are not secured.
Load curren	Ammeter	As indicated on the nameplate
Ambient temperature	Thermometer	–10 ˚C to +40 ˚C
Temperature rise	Thermometer	90˚C or below on frame surface (ambient temperature 40 ˚C)
Noise	Auditory perception	No increase in abnormal sound or noise level
Vibration	Vibrometer/feeling	No abnormal vibration
Deposition of powder dust	Visual	Flow of cooling air is not disturbed by dust and powder
Oil leakage	Visual	No oil or grease from joint to gear head or from output shaft
Insulation resistance	Insulating-resistance tester	Connect the 500 V megger across motor lead and earth terminal. The reading should be 50 MΩ or more.
Grease leakage	Visual	Check exterior and peripheral of motor and gear head for coat of grease or oil. If the leakage will affect the application, use cover as necessary for protection.
Foundation bolt	Torque wrench	Check bolts for loosening and retighten as necessary.

- **Periodic check (once/1 to 2 month)**
  - Motor: dust accumulation
  - Casing: deformation or corrosion
  - Insulation resistance: 1 MΩ or more (across frame and leads)

Operating conditions

Ambient temperature	–10 ˚C to + 40 ˚C
Ambient humidity	85 %RH or less
Altitude	1000 m or lower
Vibration	4.9 m/s² or less
Operating voltage	Nameplate rating ±10 %*
Operating voltage	50 Hz or 60 Hz as specified on the nameplate

* ±10 % is not a guaranteed value for continuous running condition.

Installation requirements

Install the geared motor at the optimal location as described below for prolonged service life.

(1) Indoor free from rain and direct sunlight

(2) Free from vibration 4.9 m/s² or more; shock, dust, iron powder or oil mist; splash of water, oil and grinding fluid; and away from flammable materials, corrosive gas (H_2S, SO_2, NO_2, Cl_2, etc.) or flammable gas.

(3) Well ventilated dry and clean location containing negligible amount of oil or dust, and away from heat source i.e. oven.

(4) Location that allows easier access for checking and cleaning of the unit.

(5) Don't use the motor in a closed environment where the motor temperature increases, shortening the life.

Selecting procedure

Determination of driving mechanism

First, determine the driving mechanism and its dimensions.
And then check the conditions required for the mechanism such as the mass of the load and traveling speed.

▼

Calculation of motor speed and load

Calculate the load torque, moment of inertia and speed which are converted to those at the motor output shaft. Refer to page A-49 to A-58 for the rotation speed, load torque and moment of inertia of the load for various mechanism.

▼

Check of required specifications

Check the required specifications such as positioning accuracy, holding of position, speed range, operating voltage and other environmental resistances for the mechanism and the machine.

▼

Selection of motor model

Select the most appropriate motor model to meet the required specifications.

▼

Temporary selection of the motor

Select the motor and gear head based on the defined speed at the motor shaft, load torque and moment of inertia of the load.

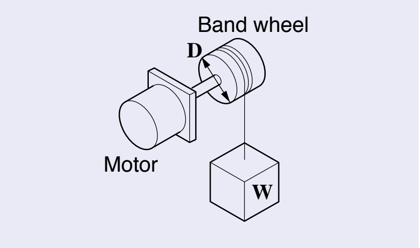
▼

Final determination of the motor and gear head

Make sure that the selected gear head and the motor combination meets all of the required specifications including mechanical strength, acceleration time and torque, then make a final determination.

Checking of load torque

Hoisting application



• SI units

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

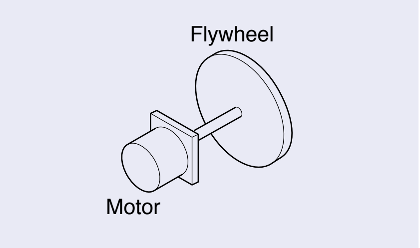
D : Diameter of drum (m)
W : Load (N)

• Gravitational system of units

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

D : Diameter of drum (m)
W : Load (kgf)

Flywheel application



• SI units

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

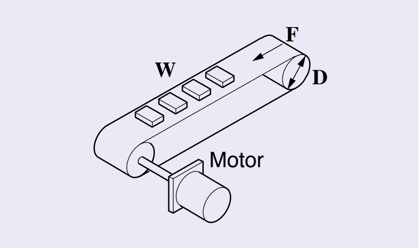
N : Rotating speed (r/min)
J : Inertia ($kg{\cdot}cm^2$)
t : Time (s)

• Gravitational system of units

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

N : Rotating speed (r/min)
GD^2 : Flywheel effect ($kgf{\cdot}cm^2$)
t : Time (s)

Belt conveyor application



• SI units

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

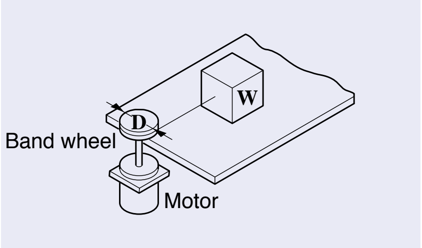
D : Diameter of roll (m)
W : Mass of load (kg)
g : Gravitational acceleration 9.8 (m/s^2)
μ : Friction coefficient
F : External force (N)

• Gravitational system of units

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

D : Diameter of roll (m)
W : Weight of load (kgf)
μ : Friction coefficient
F : External force (kgf)

Horizontal travel on contact face



• SI units

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

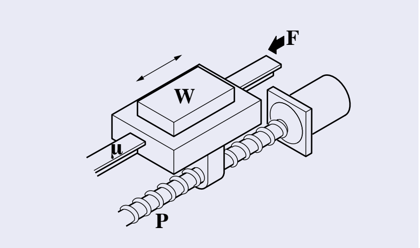
D : Diameter of drum (m)
W : Mass (kg)
g : Gravitational acceleration 9.8 (m/s^2)
μ : Friction coefficient

• Gravitational system of units

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

D : Diameter of drum (m)
W : Weight (kgf)
μ : Friction coefficient

Ball screw drive



• SI units

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

F : External force (N)
W : Mass of load (kg)
μ : Friction coefficient of sliding surfaces (approx. 0.05 to 0.2)
g : Gravitational acceleration 9.8 (m/s^2)
P : Lead of ball screw (m)

• Gravitational system of units

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

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)

Motor selection

Inertia

To describe the moment of inertia, **J** and **GD²** is used. **J** is generally called inertia and has the same value of physical moment of inertia in SI units. Unit is in **kg·m²**.
GD² (GD square) is called "flywheel effect" and generally used in industrial application with gravitational systems of units. Unit is in **kgf·m²** or **kgf·cm²**. A relation between **J** and **GD²** is described as:

$$J = GD^2 / 4$$

For the purpose of this document, both **J** for SI units and **GD²** for gravitational system of units are used. Unit of **J** should be **kg·m²** in dynamical significance, however, **kg·cm²** is used as well for convenience. Refer to pages A-54 and A-55 for calculation of **J** and **GD²** 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-54 and A-55 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_G : Inertia of gear head output shaft (kg·cm²)
J_M : Permissible inertia at motor shaft (kg·cm²)
i : Reduction ratio (e.g. 5 if the ratio is 1/5)

* The formula also applies to **GD²** 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, $J_G = J_M \times i^2$

When reduction ratio is 1/60 or larger, $J_G = J_M \times 2500$

J_G : Permissible load inertia moment at gear head output shaft (kg·cm²)
J_M : Permissible inertia at motor shaft (kg·cm²)
i : Reduction ratio (e.g. 5 if the ratio is 1/5)

Permissible inertia (J_M) at motor shaft varies with motors. To find the inertia for the motor in question, refer to tables on pages A-52 and A-53.

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·m²)
ω : Angular speed (rad/s)
t : Time (s)
n : Rotational speed (r/s)
GD² : Flywheel effect ($GD^2 = 4J$)
g : Gravitational acceleration = 9.8 (m/s²)
α : Angular acceleration (rad/s²)

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_A to accelerate the load inertia of J (kg·cm²) (GD² (kgf·cm²)) up to a speed n (r/min) in time t (s) can be obtained by the following formula.

· SI units

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

· Gravitational system of units

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

Motor selection

Inertia

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.

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 J ($kg·cm^2$)	Rotor inertia J ($oz\text{-}in^2$)	Rotor inertia GD^2 ($kgf·cm^2$)		Average acceleration torque (N·m)	Average acceleration torque (oz-in)	Average acceleration torque (kgf·cm)	Permissible load inertia at motor shaft J ($kg·cm^2$)	Permissible load inertia at motor shaft J ($oz\text{-}in^2$)	Permissible load inertia at motor shaft GD^2 ($kgf·cm^2$)
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	1.29 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	5.35 5.33	0.650	3.554	2.60
		90	2.211	12.089	8.843	50 Hz 60 Hz	0.692 0.691	98.00 97.85	7.06 7.05	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
	90 mm sq. (3.54 inch sq.)	40	1.287	7.037	5.146	50 Hz 60 Hz	0.667 0.513	94.46 72.65	6.81 5.23	0.4	2.187	1.60
		60	1.787	9.770	7.147	50 Hz 60 Hz	1.03 0.767	145.86 108.62	10.52 7.83	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	14.88 10.87	0.650	3.554	2.60

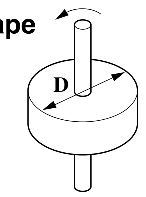
- When using single-phase reversible motor and brake unit
- When using single-phase variable speed reversible motor and electric brake of speed controller

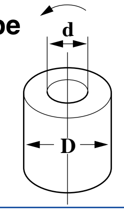
No. of phases	Size	Output (W)	Rotor inertia J ($kg·cm^2$)	Rotor inertia J ($oz\text{-}in^2$)	Rotor inertia GD^2 ($kgf·cm^2$)		Average acceleration torque (N·m)	Average acceleration torque (oz-in)	Average acceleration torque (kgf·cm)	Permissible load inertia at motor shaft J ($kg·cm^2$)	Permissible load inertia at motor shaft J ($oz\text{-}in^2$)	Permissible load inertia at motor shaft GD^2 ($kgf·cm^2$)
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
	60 mm sq. (2.36 inch sq.)	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
		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
	70 mm sq. (2.76 inch sq.)	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
		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
	80 mm sq. (3.15 inch sq.)	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
		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
	90 mm sq. (3.54 inch sq.)	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
		60	1.841	10.066	7.364	50 Hz 60 Hz	0.621 0.600	87.94 84.97	6.34 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

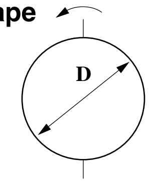
- When using single-phase electromagnetic brake motor
- When using single-phase variable speed reversible motor and electric brake of speed controller

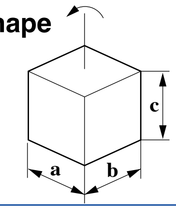
No. of phases	Size	Output (W)	Rotor inertia J ($kg·cm^2$)	Rotor inertia J ($oz\text{-}in^2$)	Rotor inertia GD^2 ($kgf·cm^2$)		Average acceleration torque (N·m)	Average acceleration torque (oz-in)	Average acceleration torque (kgf·cm)	Permissible load inertia at motor shaft J ($kg·cm^2$)	Permissible load inertia at motor shaft J ($oz\text{-}in^2$)	Permissible load inertia at motor shaft GD^2 ($kgf·cm^2$)
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
	70 mm sq. (2.76 inch sq.)	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 2.27	0.178	0.973	0.71
	90 mm sq. (3.54 inch sq.)	40	1.362	7.447	5.446	50 Hz 60 Hz	0.439 0.420	62.17 59.48	4.48 4.29	0.735	4.019	2.94
		60	1.862	10.180	7.447	50 Hz 60 Hz	0.639 0.615	90.49 87.09	6.52 6.28	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	8.77 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
	90 mm sq. (3.54 inch sq.)	40	1.362	7.447	5.446	50 Hz 60 Hz	0.667 0.513	94.46 72.65	6.81 5.23	0.735	4.019	2.94
		60	1.862	10.180	7.447	50 Hz 60 Hz	1.031 0.767	146.00 108.62	10.52 7.83	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	14.58 10.87	1	5.468	4.0

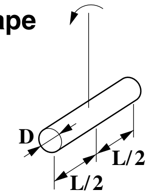
How to calculate moment of inertia

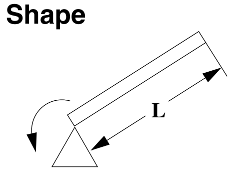
• Disk	J (Inertia calculation)	GD² (Flywheel effect calculation)
• Shape 	$J = \frac{1}{8} WD^2$ (kg·cm²) W : Mass (kg) D : Outer diameter (cm)	$GD^2 = \frac{1}{2} WD^2$ (kgf·cm²) W : Weight (kgf) D : Outer diameter (cm)

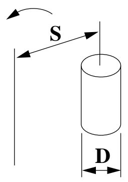
• Hollow circular cylinder	J (Inertia calculation)	GD² (Flywheel effect calculation)
• Shape 	$J = \frac{1}{8} W (D^2 + d^2)$ (kg·cm²) W : Mass (kg) D : Outer diameter (cm) d : Inner diameter (cm)	$GD^2 = \frac{1}{2} W (D^2 + d^2)$ (kgf·cm²) W : Weight (kgf) D : Outer diameter (cm) d : Inner diameter (cm)

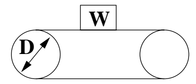
• Sphere	J (Inertia calculation)	GD² (Flywheel effect calculation)
• Shape 	$J = \frac{1}{10} WD^2$ (kg·cm²) W : Mass (kg) D : Diameter (cm)	$GD^2 = \frac{2}{5} WD^2$ (kgf·cm²) W : Weight (kgf) D : Diameter (cm)

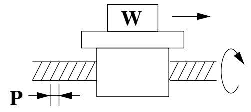
• Cube	J (Inertia calculation)	GD² (Flywheel effect calculation)
• Shape 	$J = \frac{1}{12} W (a^2 + b^2)$ (kg·cm²) W : Mass (kg) a.b : Length of side (cm)	$GD^2 = \frac{1}{3} W (a^2 + b^2)$ (kgf·cm²) W : Weight (kgf) a.b : Length of side (cm)

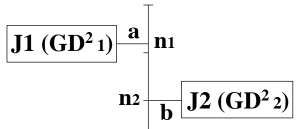
• Slender round bar	J (Inertia calculation)	GD² (Flywheel effect calculation)
• Shape 	$J = W \frac{3D^2 + 4L^2}{48}$ (kg·cm²) W : Mass (kg) D : Outer diameter (cm) L : Length (cm)	$GD^2 = W \frac{3D^2 + 4L^2}{12}$ (kgf·cm²) W : Weight (kgf) D : Outer diameter (cm) L : Length (cm)

• Straight bar	J (Inertia calculation)	GD² (Flywheel effect calculation)
• Shape 	$J = \frac{1}{3} WL^2$ (kg·cm²) W : Mass (kg) L : Length (cm)	$GD^2 = \frac{4}{3} WL^2$ (kgf·cm²) W : Weight (kgf) L : Length (cm)

• Discrete shaft	J (Inertia calculation)	GD² (Flywheel effect calculation)
• Shape 	$J = \frac{1}{8} WD^2 + WS^2$ (kg·cm²) W : Mass (kg) D : Diameter (cm) S : Turning radius (cm)	$GD^2 = \frac{1}{2} WD^2 + 4WS^2$ (kgf·cm²) W : Weight (kgf) D : Diameter (cm) S : Turning radius (cm)

• Horizontal linear motion	J (Inertia calculation)	GD² (Flywheel effect calculation)
• Shape 	$J = \frac{WD^2}{4}$ (kg·cm²) W : Mass on the conveyor (kg) D : Drum diameter (cm) * Inertia of drum not included	$GD^2 = WD^2$ (kgf·cm²) W : Weight on the conveyor (kgf) D : Drum diameter (cm) * Flywheel effect of drum not included

• Ball screw	J(Inertia calculation)	GD² (Flywheel effect calculation)
• Shape 	$J = J_A + \frac{W \cdot P^2}{4\pi^2}$ (kg·cm²) W : Mass (kg) P : Lead of feed screw (cm) JA : Inertia of feed screw (kg·cm²)	$GD^2 = GD^2_A + \frac{W \cdot P^2}{\pi^2}$ (kgf·cm²) W : Weight (kgf) P : Lead of feed screw (cm) GD^2_A : Flywheel effect of feed screw (kgf·cm²)

• Reducer	J (Inertia calculation)	GD² (Flywheel effect calculation)
• Shape 	Equivalent all inertia on axis "a" $J = J1 + \left(\frac{n_2}{n_1}\right)^2 J2$ (kg·cm²) n_1 : Speed of axis "a" (r/min) n_2 : Speed of axis "b" (r/min) J1 : J of axis "a" (kg·cm²) J2 : J of axis "b" (kg·cm²)	Equivalent all flywheel effect on axis "a" $GD^2 = GD^2_1 + \left(\frac{n_2}{n_1}\right)^2 GD^2_2$ (kgf·cm²) n_1 : Speed of axis "a" (r/min) n_2 : Speed of axis "b" (r/min) GD^2_1 : GD² of axis "a" (kgf·cm²) GD^2_2 : GD² of axis "b" (kgf·cm²)

Motor selection

Service factor

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)
Ball bearing	10000 hours*
Metal bearing	2000 hours
Right-angle	5000 hours

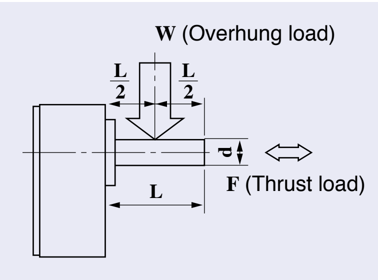
	Life (hours)
42 mm sq.	2000 hours
Round shaft	10000 hours*
for C&B motor	5000 hours

* 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.



	Size		Output	Permissible overhung load (W)		Permissible thrust load (F)	
				N (kgf)	lbf	N (kgf)	lbf
Motor unit (round shaft)	42 mm sq. (1.65 inch sq.)	4P	1 W	39 (4)	8.8	1.5 (0.15)	0.3
		2P	3 W	39 (4)	8.8	1.5 (0.15)	0.3
	60 mm sq. (2.36 inch sq.)	4P	3 W to 6 W	49 (5)	11	7 (0.7)	1.5
	70 mm sq. (2.76 inch sq.)	4P	10 W to 15 W	49 (5)	11	7 (0.7)	1.5
	80 mm sq. (3.15 inch sq.)	4P	15 W to 25 W	108 (11)	24	12 (1.2)	2.6
		2P	20 W to 60 W	118 (12)	26	12 (1.2)	2.6
	90 mm sq. (3.54 inch sq.)	4P	40 W	157 (16)	35	20 (2)	4.4
		4P	60 W to 90 W	255 (26)	56	20 (2)	4.4
		2P	60 W	118 (12)	26	20 (2)	4.4
		2P	90 W to 150 W	147 (15)	33	20 (2)	4.4

MX□G, MZ9G, MY9G, MR9G, MP9G type

Size	Model	Permissible overhung load (W)		Permissible thrust load (F)	
		N (kgf)	lbf	N (kgf)	lbf
42 mm sq. (1.65 inch sq.)	M4GA□F	20 (2)	4.4	15 (1.5)	3.3
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	147 (15)	33
	MY9G□B				
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

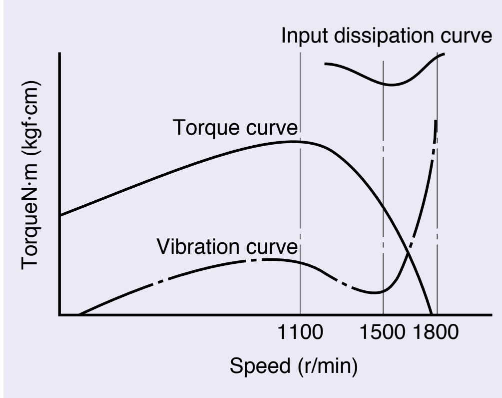
Calculation of motor capacity

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 [r/min] to 1800 [r/min] according to the load. The speed most suitable for the load of the equipment is as follows:
1200 [r/min] to 1250 [r/min] for 50 Hz
1500 [r/min] to 1550 [r/min] 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)

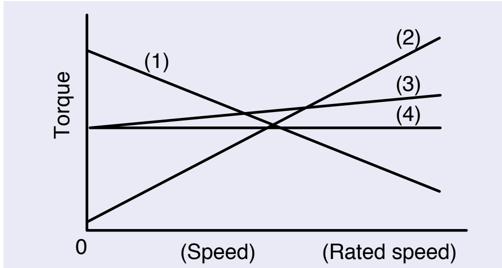


2. Examination of load of equipment

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.

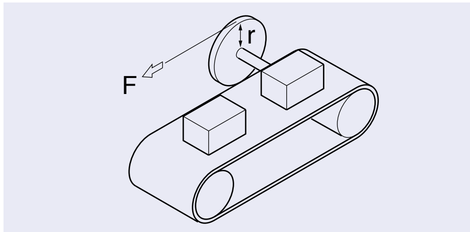
Fig. 2 Type of Load



3. Calculation of required torque

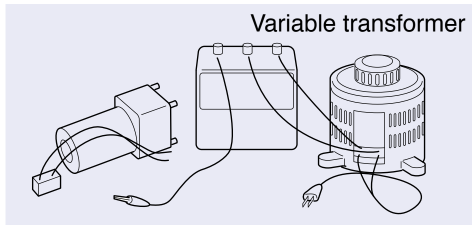
· When the load of the equipment is (1), (3) or (4) in Fig. 2
Calculate the approximate value of the required starting torque Ts. In Fig. 3 (Conveyor), for example, calculate the required force F from "T = Fr". Then select suitable motors from our catalog or the attached S-T data and check the minimum 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 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.

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.

$$n = i \times n_1$$

- n : Motor speed (r/min)
- n_1 : Speed of gear output shaft or pulley etc. attached to it (r/min)
- 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 r/min
Working condition : Continuous
Frequency : 60 Hz
Select a motor that meet the above.

(1) Speed suitable for specifications
Because the required speed is 30 r/min, the gear ratio that realizes a rated motor speed (60 Hz area) of 1500 r/min to 1550 r/min 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 r/min

(4) From speed-torque curve of 4-pole 25 W induction motor
Ts : Starting torque **Ts = 0.16 N·m (22.66 oz-in)**
Tm : Stalling torque **Tm = 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)

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

(Minimum required stalling torque)

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

(Torque at motor speed of 1700 r/min)

= 0.12 N·m (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, Ts and Tm of the 4-pole 15 W induction motor are as follows:
Ts = 0.1 N·m (14.16 oz-in)
Tm = 0.15 N·m (21.24 oz-in)

Considering the voltage drop and variation when used for conveyors, Ts and Tm of the 4-pole 15 W induction motor at 90 V are assumed to be as follows:
Ts = 0.08 N·m (11.33 oz-in)
Tm = 0.12 N·m (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)

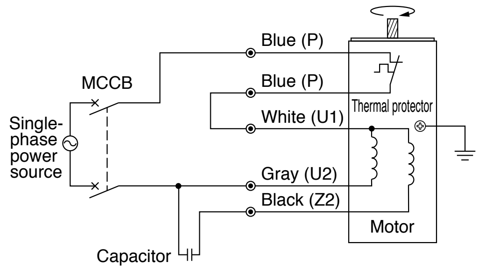
This law is a domestic law in Japan intended to regulate the manufacture, sale, etc. of electrical appliances and to prevent the occurrence of fire, electric shock, injury, etc. attributable to electrical appliances by promoting self-activities of private enterprises for ensuring the safety of electrical 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
UL1004-1 (motor) : Provisions concerning motor construction and material
UL1004-2 (thermal protection of motor) : Provisions concerning impedance protection of motor
UL1004-3 (thermal protection of motor) : Provisions concerning thermal protection of motor
UL840 (insulation coordination of equipment) : Provisions concerning base items of motor insulation

· Conformance to UL and CSA

· UL1004-1 **· CSA C22.2 No.100**	All products conform to these standards.
· UL1004-2 **· CSA C22.2 No.77**	6 W motors conform to these standards.
· UL1004-3 **· CSA C22.2 No.77**	· Single-phase 2-pole motors conform to these standards. · These standards do not apply to single-phase 15 to 90 W 4-pole motors wired as shown in wiring diagrams on pp. A-60 to A-61. For example, when the thermal protector is connected in series between power line and motor white terminal (U1), this circuit becomes compatible. · These standards do not apply to 3-phase motors. 

Safety standard approved motor

EN Standard (to be considered when exporting motors to Europe)

It is a safety standard applied within the EU/UK borders, most part of which is based on the IEC standard. In Europe, the power supply voltage is as high as single-phase 230 V and 3-phase 400 V and it is therefore necessary to give consideration to electric shock in particular (Low Voltage Directive). In addition, because the mechanical safety (Machinery Directive) is considered, there is a recognition that it is dangerous for a motor to move suddenly as a result of automatic resetting of the protector etc. It is therefore required that, after the occurrence of an abnormal condition activating the protector, the machine can be started only when manual resetting is made by the operator. It is necessary to put a CE mark (EU) / UKCA mark (UK) on products that have passed the test of the EN standard and are to be exported and to show clearly their safety level. (The product level is specified in the instruction manual. In Europe, when a (safety) self-declaration is required by a user, it should be submitted to the user.) In the case of a motor with speed controller, it is necessary to show clearly the level of malfunction (including malfunction of the motor and damage to other equipment) due to electromagnetic interference. (Check the level individually.) This level is evaluated based on the motor and controller alone. Because electromagnetic interference varies significantly depending on the wiring for incorporation into equipment, this level should be regarded as a reference value and a final determination should be made after incorporation into equipment.

· **EN standard on motor**

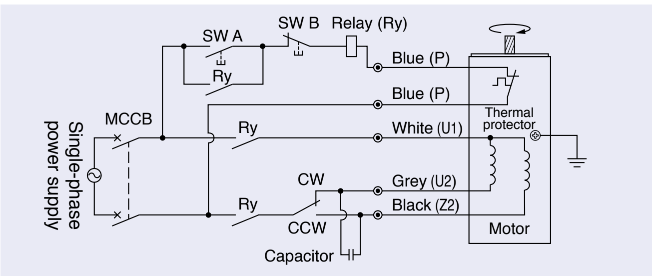
Low Voltage Directive: Directive for 50 VAC to 1000 VAC equipment

EN60034 (rating of electric machine)	: Provisions concerning general items on motor
EN60664 (insulation coordination of equipment)	: Provisions concerning base items of motor insulation
EN60204 (electric equipment of industrial machinery)	: Provisions concerning industrial motor

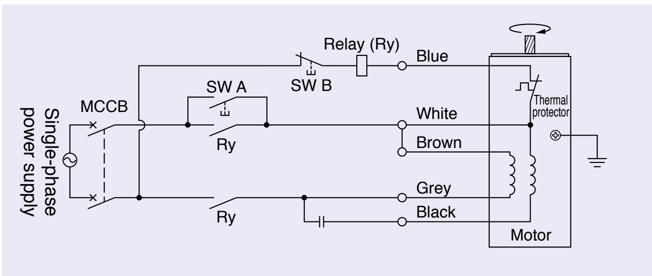
Representative Wiring of Safety Standard Approved Motor

(1) The customer should verify conformance to the standards, laws, etc. on the completed equipment.
(2) The thermal protector Ⓣ is **an automatic reset type**. To prevent hazardous unintentional restart, it must be wired as shown in the figure below.
(Connect a spark killer to the electromagnetic contactor.)
Do not connect the thermal protector Ⓣ directly to the power source. Instead, connect it to the source through the switch SW A and SW B and relay Ⓡ.
(3) Voltage of the thermal protector is the maximum rating AC250 V.
* Connection of the following is an example of the CW direction (clockwise) as viewed from the load side of the motor shaft.

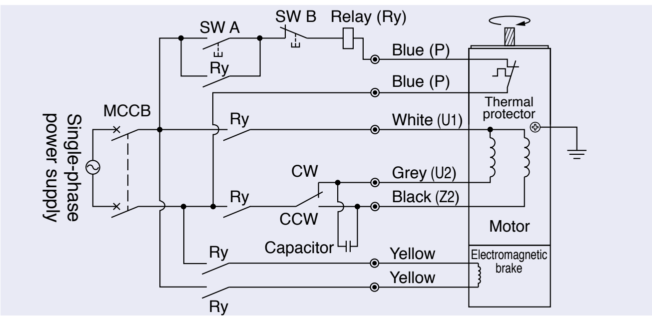
• **70 mm sq. to 90 mm sq.**
Wiring example of 4 pole induction motor and reversible motor.



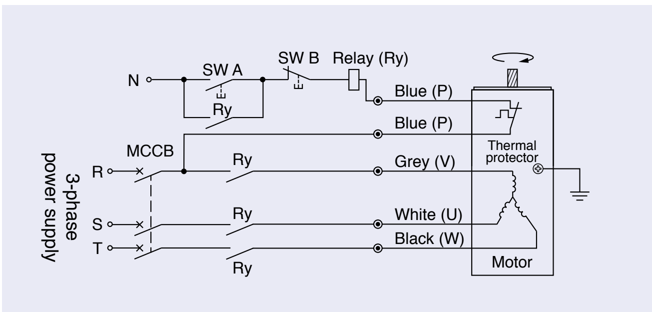
• **Wiring example of 2 pole induction motor**



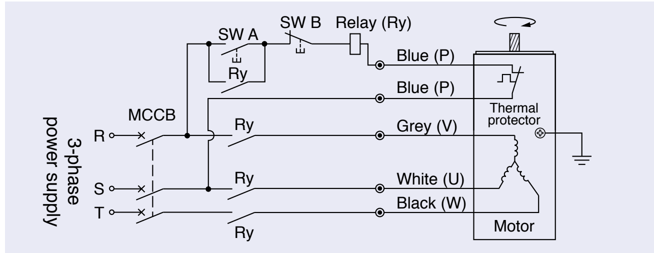
• **70 mm sq. to 90 mm sq.**
Wiring example of 4 pole single-phase motor with electromagnetic brake.



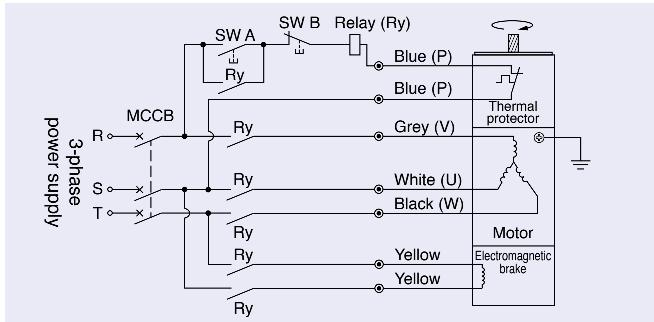
• **Wiring example of 2-pole, 4-pole 3-phase motor.**
Connect between 3-phase power supply R and neutral point N.



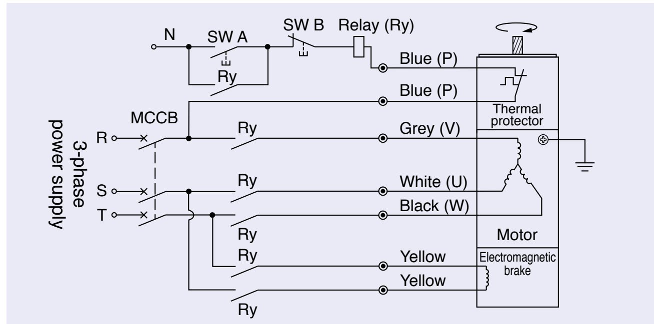
• **Wiring example of 2-pole, 4-pole 3-phase motor.**
(200 V/220 V/230 V)



• **Wiring example of 4 pole 3-phase motor with electromagnetic brake.**
(200 V/220 V/230 V)



• **Wiring example of 4 pole 3-phase motor with electromagnetic brake.**
Connect between 3-phase power supply R and neutral point N.



· When using the AC380 V/400 V 3-phase motor, please connect to be applied voltage to AC250 V from AC100 V between the lines of thermal protector (blue blue).

GB Standard (to be considered when exporting motors to China)

In the People's Republic of China, China Compulsory Certification (CCC) is applied to products affecting health and safety of people, life and safety of animals and plants, environmental protection and public safety. Our motors are subject to CCC (excluding some motors) and a CCC certification mark is put on the main body of a certified motor.

· **GB standard on motor**

GB12350: Standard on safety of motor
GB25958: Standard on energy efficiency of motor
(For GB standard compliant products, please refer to the model list page of each breed.)

Export consideration

When export this product, follow statutory provisions of the destination country.

Safety standard approved motor

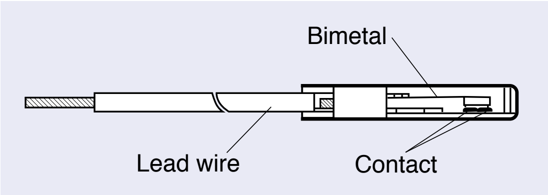
Overheat protection device

If a motor in operation is locked due to overloading or the input is increased for some reason, the temperature of the motor will rise rapidly. If the motor is left in this condition, the insulating performance in the motor will be deteriorated, leading to shortening of the life and, in the worst case, burning of the coil. In order to protect motors from such abnormal heating, our motors compliant with overseas standards are equipped with the following overheat protection device.

• Motor with thermal protector

In the case of the motors with mounting surface dimensions of 70 mm sq., 80 mm sq. and 90 mm sq., an automatic-reset thermal protector is incorporated.
The construction of the thermal protector is shown in the figure to the right. The thermal protector is of bimetallic type and silver or silver alloy, which has low electrical resistance and high thermal conductivity, is used for the contacts.

• Construction of thermal protector (Automatic reset type)



Operating temperature of thermal protector

<International standard approved>	<Japanese version / Variable speed motor 90 W>
open........130± 5 ˚C	open........120± 5 ˚C
close......... 90±15 ˚C	close......... 77±15 ˚C

(When the thermal protector is operating, the temperature of the coil is slightly higher than the operating temperature shown above.)
Test: It has passed a lock test of 18 days straight.

• Impedance protected motor

It is applied to the motors with mounting surface dimensions of 60 mm sq.. The impedance of the coil of the impedance protected motor is made higher so as to make smaller the current (input) increase when the motor is locked, preventing the temperature rise from exceeding a certain level. Test: It has passed a lock test of 18 days straight.

General specifications for safety standard motor

Insulation resistance:
The value measured between the coil and case with a 500 VDC megger after continuous operation at normal temperature and humidity should be 50 MW or more.

Dielectric strength:
No anomaly should be found when 1.5 kV, 60 Hz is applied to between the coil and case for one minute after continuous operation at normal temperature and humidity.

Standard / Test Item	Electrical Appliance and Material Safety Law
150 V or lower	1000 V for one minute
Higher than 150 V	1500 V for one minute

The EN standard, IEC standard and GB standard specify 1500 V for one minute.

Overheat protection system:
The motors with mounting surface dimensions of 60 mm sq. is impedance-protected. The other motors incorporate an automatic-reset thermal protector.

Heat resistance class:
Specifications compliant with overseas standards Heat resistance class 130 (B)

Operating ambient temperature range:
–10 ˚C to +40 ˚C

Operating ambient humidity range:
85 % RH or less

Altitude:
1000 m or less

Vibration:
4.9 m/s^2 or less

Working power supply voltage:
Rated voltage (value shown on nameplate) ±10 % means a power supply voltage fluctuation range and does not refer to voltage that can be used at any time.

Working power supply frequency:
50 Hz/60 Hz (Value shown on nameplate)