FANUC

GE Fanuc Automation

Computer Numerical Control Products

AC Spindle Motor βi Series

Descriptions Manual

GFZ-65312EN/01 *May 2003*

Warnings, Cautions, and Notes as Used in this Publication

Warning

Warning notices are used in this publication to emphasize that hazardous voltages, currents, temperatures, or other conditions that could cause personal injury exist in this equipment or may be associated with its use.

In situations where inattention could cause either personal injury or damage to equipment, a Warning notice is used.

Caution

Caution notices are used where equipment might be damaged if care is not taken.

Note

Notes merely call attention to information that is especially significant to understanding and operating the equipment.

This document is based on information available at the time of its publication. While efforts have been made to be accurate, the information contained herein does not purport to cover all details or variations in hardware or software, nor to provide for every possible contingency in connection with installation, operation, or maintenance. Features may be described herein which are not present in all hardware and software systems. GE Fanuc Automation assumes no obligation of notice to holders of this document with respect to changes subsequently made.

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SAFETY PRECAUTIONS

This "Safety Precautions" section describes the precautions which must be observed to ensure safety when using FANUC spindle motors.
Users of any spindle motor model are requested to read this manual carefully before using the spindle motor.
The users are also requested to read this manual carefully and understand each function of the motor for correct use.
The users are basically forbidden to do any behavior or action not mentioned in this manual. They are invited to ask FANUC previously about what behavior or action is prohibited.

For matters that are not described in this manual, a machine must be designed and assembled in accordance with EN60204-1 to ensure the safety of the machine and compliance with European specifications. For details, refer to the specification.

Contents

1.1 DEFINITION OF WARNING, CAUTION, AND NOTE

This manual includes safety precautions for protecting the user and preventing damage to the machine. Precautions are classified into Warning and Caution according to their bearing on safety. Also, supplementary information is described as a Note. Read the Warning, Caution, and Note thoroughly before attempting to use the machine.

> ⚠ **WARNING**
> Applied when there is a danger of the user being injured or when there is a damage of both the user being injured and the equipment being damaged if the approved procedure is not observed.

> ⚠ **CAUTION**
> Applied when there is a danger of the equipment being damaged, if the approved procedure is not observed.

> **NOTE**
> The Note is used to indicate supplementary information other than Warning and Caution.

- Read this manual carefully, and store it in a safe place.

1.2 WARNING

⚠ WARNING

- Be safely dressed when handling a motor.

Wear safety shoes or gloves when handling a motor as you may get hurt on any edge or protrusion on it or electric shocks.

- Use a crane or lift to move a motor from one place to another.

A motor is heavy. If you lift the motor by hand, you may get a backache, or you may be seriously injured when you drop the motor. A suitable crane or lift must be used to move the motor. (For the weight of motors, refer to this manual.)
When moving a motor using a crane or lift, use a hanging bolt if the motor has a corresponding tapped hole, or textile rope if it has no tapped hole. If a motor is attached with a machine or any other heavy stuff, do not use a hanging bolt to move the motor as the hanging bolt and/or motor may get broken.

- Before starting to connect a motor to electric wires, make sure they are isolated from an electric power source.

A failure to observe this caution is vary dangerous because you may get electric shocks.

- Be sure to secure power wires.

If operation is performed with a terminal loose, the terminal block may become abnormally hot, possibly causing a fire. Also, the terminal may become disconnected, causing a ground fault or short-circuit, and possibly giving you electric shocks. See the section in this manual that gives the tightening torque for attaching power wires and short-bars to the terminal block.

- Be sure to ground a motor frame.

To avoid electric shocks, be sure to connect the grounding terminal in the terminal box to the grounding terminal of the machine.

- Do not ground a motor power wire terminal or short-circuit it to another power wire terminal.

A failure to observe this caution may cause electric shocks or a burned wiring.

- Do not supply the power to the motor while any terminal is exposed.

A failure to observe this caution is very dangerous because you may get electric shocks if your body or any conductive stuff touches an exposed terminal.

⚠ WARNING

- Do not bring any dangerous stuff near a motor.

Motors are connected to a power line, and may get hot. If a flammable is placed near a motor, it may be ignited, catch fire, or explode.

- Do not get close to a rotary section of a motor when it is rotating.

You may get your clothes or fingers caught in a rotary section, and may be injured. Before starting a motor, ensure that there is no stuff that can fly away (such as a key) on the motor.

- Do not touch a motor with a wet hand.

A failure to observe this caution is vary dangerous because you may get electric shocks.

- Before touching a motor, shut off the power to it.

Even if a motor is not rotating, there may be a voltage across the terminals of the motor.
Especially before touching a power supply connection, take sufficient precautions.
Otherwise you may get electric shocks.

- Do not touch any terminal of a motor for a while (at least 5 minutes) after the power to the motor is shut off.

High voltage remains across power line terminals of a motor for a while after the power to the motor is shut off. So, do not touch any terminal or connect it to any other equipment. Otherwise, you may get electric shocks or the motor and/or equipment may get damaged.

- To drive a motor, use a specified amplifier and parameters.

An incorrect combination of a motor, amplifier, and parameters may cause the motor to behave unexpectedly. This is dangerous, and the motor may get damaged.

- Before driving a motor, be sure to secure it.

If a motor is drove without being secured, it may roll over during acceleration or deceleration, injuring the user.

1.3 CAUTION

⚠ CAUTION

- Do not touch a motor when it is running or immediately after it stops.

A motor may get hot when it is running. Do not touch the motor before it gets cool enough. Otherwise, you may get burned.

- Be careful not get your hair or cloths caught in a fan.

Be careful especially for a fan used to generate an inward air flow.
Be careful also for a fan even when the motor is stopped, because it continues to rotate while the amplifier is turned on.

- FANUC motors are designed for use with machines. Do not use them for any other purpose.

If a FANUC motor is used for an unintended purpose, it may cause an unexpected symptom or trouble. If you want to use a motor for an unintended purpose, previously consult with FANUC.

- Ensure that a base or frame on which a motor is mounted is strong enough.

Motors are heavy. If a base or frame on which a motor is mounted is not strong enough, it is impossible to achieve the required precision.

- Ensure that motors and related components are mounted securely.

If a motor or its component slips out of place or comes off when the motor is running, it is very dangerous.

- Be sure to connect motor cables correctly.

An incorrect connection of a cable cause abnormal heat generation, equipment malfunction, or failure. Always use a cable with an appropriate current carrying capacity (or thickness). For how to connect cables to motors, refer to their
respective specification manuals.

- Ensure that motors are cooled if they are those that require forcible cooling.

If a motor that requires forcible cooling is not cooled normally, it may cause a failure or trouble. For a fan-cooled motor, ensure that it is not clogged or blocked with dust and dirt. For a liquid-cooled motor, ensure that the amount of the liquid is appropriate and that the liquid piping is not clogged. For both types, perform regular cleaning and inspection.

- When attaching a component having inertia, such as a pulley, to a motor, ensure that any imbalance between the motor and component is minimized.

If there is a large imbalance, the motor may vibrates abnormally, resulting in the motor being broken.

⚠ CAUTION

- Be sure to attach a key to a motor with a keyed shaft.

If a motor with a keyed shaft runs with no key attached, it may impair torque transmission or cause imbalance, resulting in the motor being broken.With the β*i* series, a shaft with no key is used as standard.

1.4 NOTE

NOTE

- Do not step or sit on a motor.

If you step or sit on a motor, it may get deformed or broken. Do not put a motor on another unless they are in packages.

- When storing a motor, put it in a dry (non-condensing) place at room temperature (0 to 40 °C).

If a motor is stored in a humid or hot place, its components may get damaged or deteriorated. In addition, keep a motor in such a position that its shaft is held horizontal and its terminal box is at the top.

- Do not remove a nameplate from a motor.

If a nameplate comes off, be careful not to lose it. If the nameplate is lost, the motor becomes unidentifiable, resulting in maintenance becoming impossible. For a nameplate for a built-in spindle motor, keep the nameplate with the spindle.

- Do not apply shocks to a motor or cause scratches to it.

If a motor is subjected to shocks or is scratched, its components may be adversely affected, resulting in normal operation being impaired. Be very careful when handling plastic portions, sensors, and windings, because they are very liable to break. Especially, avoid lifting a motor by pulling its plastic portion, winding, or power cable.

- Do not conduct dielectric strength or insulation test for a sensor.

Such a test can damage elements in the sensor.

- When testing the winding or insulation resistance of a motor, satisfy the conditions stipulated in IEC34.

Testing a motor under a condition severer than those specified in IEC34 may damage the motor.

- Do not disassemble a motor.

Disassembling a motor may cause a failure or trouble in it.
If disassembly is in need because of maintenance or repair, please contact a service representative of FANUC.

- Do not modify a motor.

Do not modify a motor unless directed by FANUC. Modifying a motor may cause a failure or trouble in it.

- Use a motor under an appropriate environmental condition.

Using a motor in an adverse environment may cause a failure or trouble in it. Refer to their respective specification manuals for details of the operating and environmental conditions for motors.

NOTE

- Do not apply a commercial power source voltage directly to a motor.

Applying a commercial power source voltage directly to a motor may result in its windings being burned. Be sure to use a specified amplifier for supplying voltage to the motor.

- For a motor with a terminal box, make a conduit hole for the terminal box in a specified position.

When making a conduit hole, be careful not to break or damage unspecified portions. Refer to an applicable specification manual.

- Before using a motor, measure its winding and insulation resistances, and make sure they are normal.

Especially for a motor that has been stored for a prolonged period of time, conduct these checks. A motor may deteriorate depending on the condition under which it is stored or the time during which it is stored. For the winding resistances of motors, refer to their respective specification manuals, or ask FANUC. For insulation resistances, see the following table.

- To use a motor as long as possible, perform periodic maintenance and inspection for it, and check its winding and insulation resistances.

Note that extremely severe inspections (such as dielectric strength tests) of a motor may damage its windings. For the winding resistances of motors, refer to their respective specification manuals, or ask FANUC. For insulation resistances, see the following table.

MOTOR INSULATION RESISTANCE MEASUREMENT

Measure an insulation resistance between each winding and motor frame using an insulation resistance meter (500 VDC). Judge the measurements according to the following table.

Insulation resistance	Judgment
100 MΩ or higher	Acceptable
10 to 100 MΩ	The winding has begun deteriorating. There is no problem with the performance at present. Be sure to perform periodic inspection.
1 to 10 MΩ	The winding has considerably deteriorated. Special care is in need. Be sure to perform periodic inspection.
Lower than 1 MΩ	Unacceptable. Replace the motor.

PREFACE

The models covered by this manual, and their abbreviations are:

Series	Model
β*i* series	β3/10000*i*, β6/10000*i*, β8/8000*i*, β12/7000*i*

TABLE OF CONTENTS

I. MOTOR TYPES AND USAGE

1 MOTOR TYPES

Each model includes the types of motors listed below, and the user can make an optimal choice according to the spindle driving structure. See the ordering list (B-65311EN) for available motors.

Item	Type	Use	Remarks
Mounting types	Flange mounting type	Connected to spindle via a gear Directly connected to a spindle Connected to spindle via a belt	The motor can be positioned accurately.
	Foot mounting type	Connected to spindle via a belt	
Built-in sensor	M*i* sensor	When connected to the spindle via a belt or gear at a deceleration ratio other than 1:1 (When the spindle has a sensor)	For a detailed explanation, refer to the following descriptions: SERVO AMPLIFIER β*i* series DESCRIPTIONS (B-65322EN)
	MZ*i* sensor	When connected to the spindle via a belt, gear, or coupling on a 1:1 basis (When the spindle has no sensor)	
Shaft figure	With no key	Connected to a pulley	A shaft with no key is used as standard to facilitate pulley and gear balance correction and acceleration/ deceleration operation. When a shaft with a key is needed, contact your FANUC sales representative.
Cooling air exhaust direction	Rearward exhaust (Exhaust from side opposite the output shaft)	When the machine is positioned at the output shaft side	Direct the exhaust out and away from the machine.
	Forward exhaust (Exhaust from the output shaft side)	When the machine is positioned at the side opposite the output shaft	
Output shaft seal	Oil seal	Gear connection, direct connection, and belt driving	Used in flange mounting type standard-speed models.
	Labyrinth	Belt driving and direct connection (Only when no lubricant or coolant splashes onto the flange surface of the motor)	Used in flange mounting type high-speed models. (Some high-speed models have an oil seal.)
	No seal	Belt driving (Only when no lubricant splashes onto the flange surface of the motor)	Foot-mounting type models have no output shaft seal, but can be changed to a model with an oil seal or labyrinth. For the models that can be changed, refer to "Order List" (B-65311EN).

2 NOTES ON INSTALLATION

2.1 COMMON

Be sure to observe the following, regardless of the connection method of the motor:

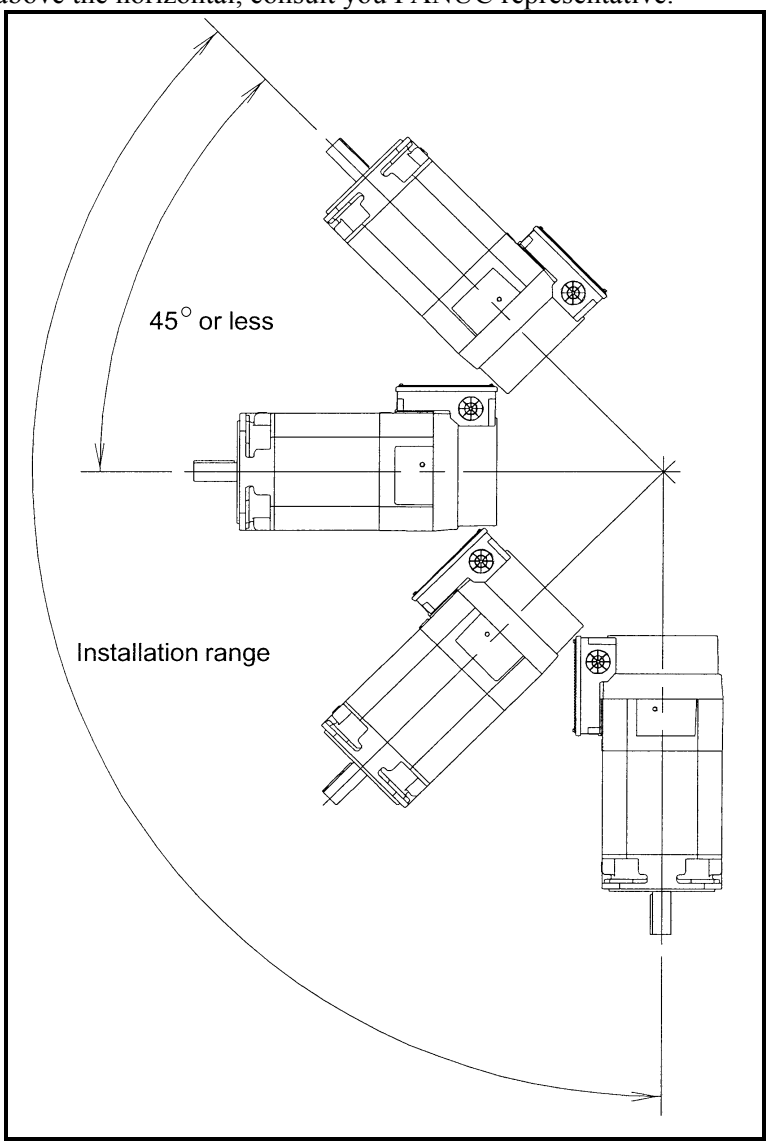
⚠ WARNING

When connecting a metallic conduit to a plastic terminal box, connect the conduit to ground on the power magnetics cabinet side.

⚠ CAUTION

1 Mount the motor so that the output shaft points in a direction ranging within 45° degrees above the horizontal to vertically downwards.

2 When the motor needs to be pointed to more than 45° degrees above the horizontal, consult you FANUC representative.



3 Use the eyebolt of the motor to lift only a single motor, (gear and pulley may be attached).

4 Place a cover over an air-cooled motor to prevent the motor from being exposed to coolant or lubricant.

5 Limit the vibration acceleration at the rear bracket of the motor to 0.5 G (4.9 m/s^2) to ensure the long-term reliability of each part of the motor.
In particular, to limit the acceleration in the case of direct connection to 0.5 G, carefully perform centering with the mating spindle and make the motor shaft parallel with the spindle.

Details of the measuring method

Measuring instrument:

Equivalent to the VM-3314A or VM-3304 manufactured by IMV CORPORATION.

Condition: At the time of highest-speed rotation with no load

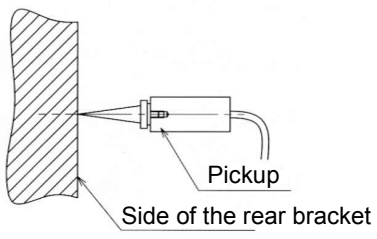
Measurement frequency range with no load at the highest speed:

10 to 1000 Hz

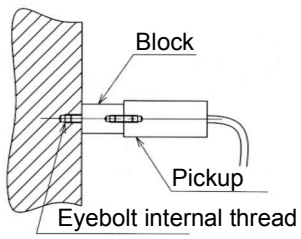
Criteria: 0.5 G (4.9 m/s^2) or less at the rear bracket

1. Using a pickup

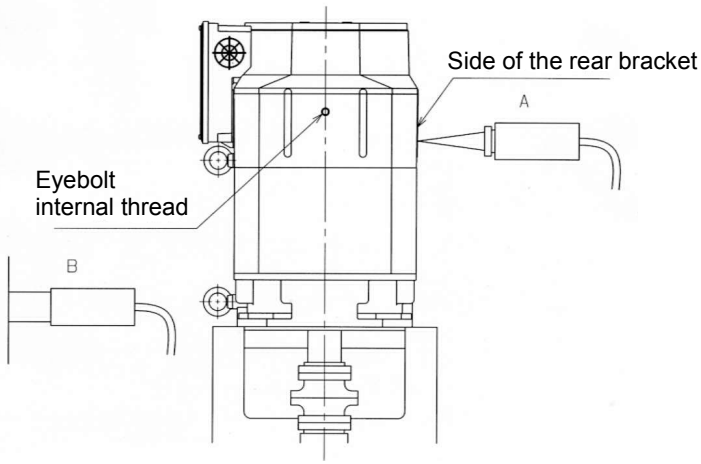
A. Pressing a pickup against the side of the rear bracket



B. Screwing a block into the eyebolt internal thread on the rear bracket, then screwing a pickup into the block.



2. Vibration measurement position (rear bracket)



6 Dynamic balance

During high-speed operation, a small imbalance may cause a large vibration, resulting in an unusual sound, premature bearing damage, or some other abnormality.

Therefore, reduce the amount of the imbalance with the dynamic balance of the other rotation shafts, as well as the gear and pulley mounted on the output shaft of the motor, as much as possible.

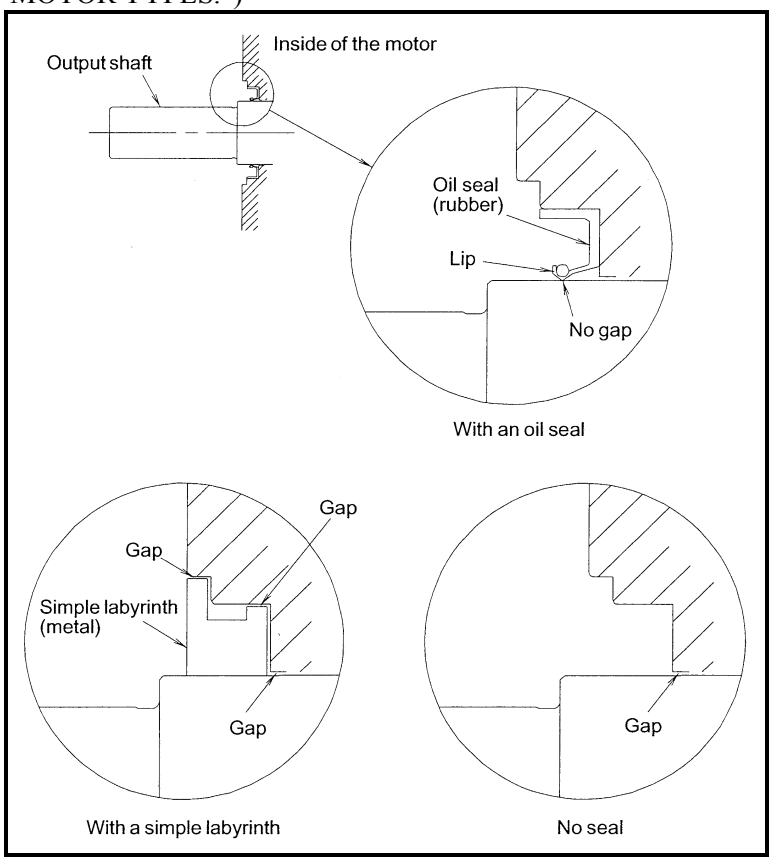
- Balance correction

With the β*i* series, a shaft with no key is used as standard to facilitate the balance correction of a pulley, gear, and coupling attached to the shaft. Use a completely symmetric pulley, gear, or coupling, and use a backlash-less tightening part such as a SPANN ELEMENTE to secure a pulley, gear, or coupling to the shaft. When attaching a pulley to a shaft, for example, adjust the periphery vibration to within 20 μm. This basically eliminates the need for balance correction. To further reduce the vibration level, make a field balance correction, for example, by tightening a screw into the tapped hole for balance correction provided on a component such as a pulley.

NOTE
When a shaft with a key is required, contact your FANUC sales representative.

7 Output shaft seal

To prevent cutting lubricant or dust from penetrating inside the motor, one of the following output shaft seals is provided on the output shaft. (For the use and applicable motors, see Chapter 1, "MOTOR TYPES.")

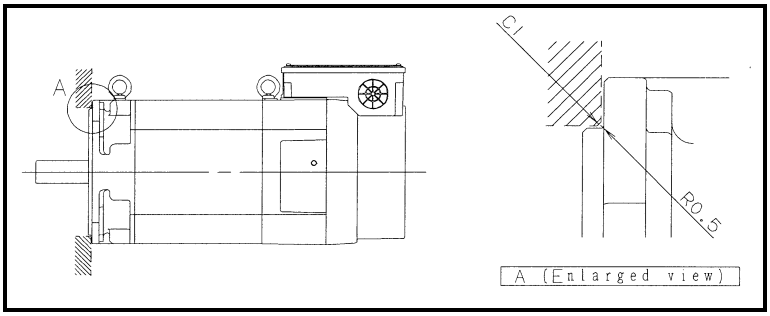


For those models with an oil seal, ensure that the surface of the lubricant is below the lip of the oil seal.

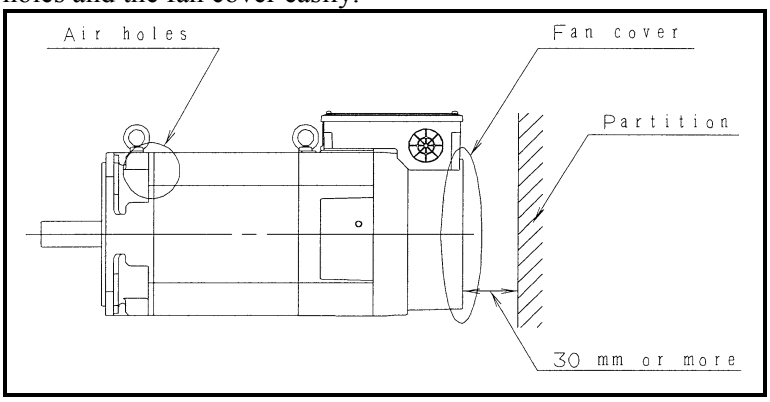
If a simple labyrinth is used as the output shaft seal (high-speed model) or if no seal is provided (foot mounting type), ensure that lubricant does not splash onto the flange surface. (If such a motor is directly mounted on a gear box, the lubricant may gradually penetrate inside the motor even when no lubricant splashes on flange surface, thus resulting in motor failure. Therefore, do not mount such a motor on a gear box directly.

8 The lid of the terminal box is provided with rubber gasket to make it waterproof.
Check that the lid has this gasket, then mount it on the terminal box.

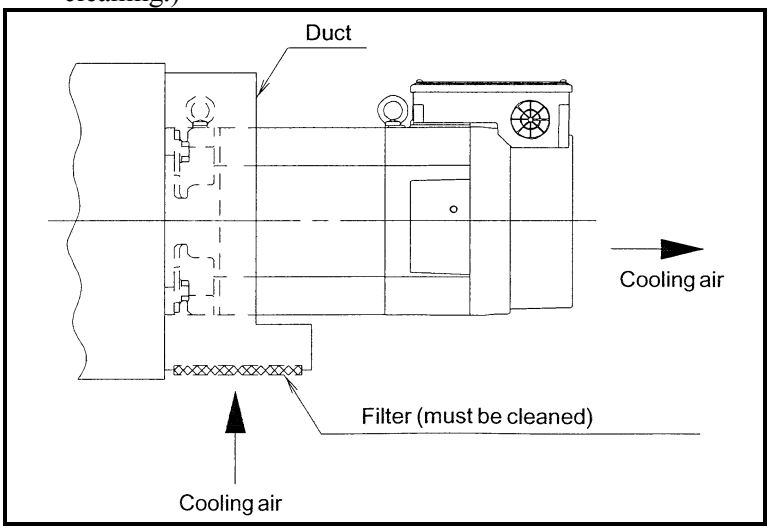
9 The edge of the fauset joint to mount the flange mounting type motor should be chamfered about C1.



10 Please space 30 mm or more between the fan cover and the partition to keep the cooling ability well.
We recommend to take a structure such as you can clean air holes and the fan cover easily.



11 If much oil mist, dust, or other foreign matter settles on the motor, the cooling performance is degraded, resulting in degraded performance of the motor. Design the machine such that only clean cooling air is drawn into the motor.
Example)
When a duct with a filter is installed on a flange mounting type motor with a rear exhaust (The filter requires periodic cleaning.)

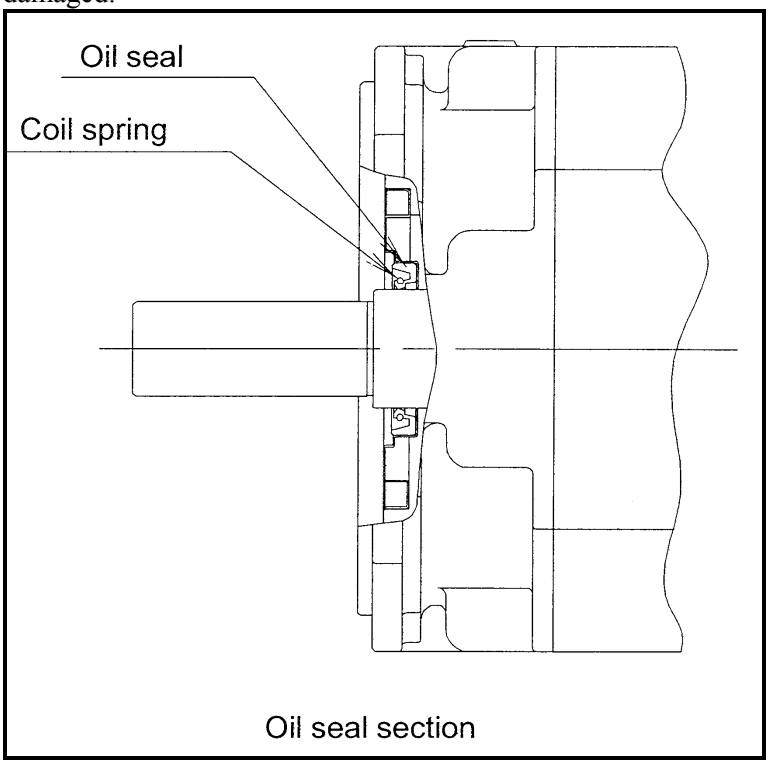


NOTE

1 A foot mounting type motor has no oil seal. When an oil seal is required, add #0002 to the drawing number of the motor.
For details, refer to "Order List" (B-65311EN).
Example)

Model β12/7000*i* (foot mounting type, with no key, rearward exhaust)
A06B-1447-B200
A06B-1447-B200#0002 (with oil seal)

2 When the oil seal is not exposed to lubricant, remove the coil spring of the oil seal to decrease the friction between the lip and shaft.
There is no problem with dry dust sealing.
If the motor is turned at high speed with the contact section between the oil seal and shaft being dry, the contact section can make an abnormal sound (interfering sound), or the lip can be damaged.



Oil seal section

3 Cable wiring

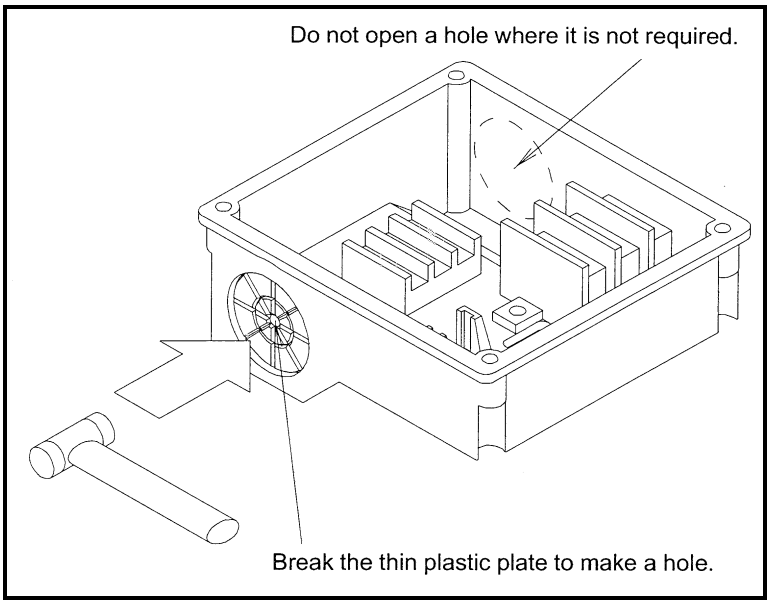
Follow the procedure below to install the cable.

(1) Use a hammer to strike the portion for the cable hole on the terminal box and open the hole.
This time, pay attention not to break the other place except hole.

(2) Thread the cable through a conduit. Connect the conduit with the connector.

(3) Tighten the connector at the cable hole of the terminal box using a nut. (*1, *2)

(4) Connect each terminal appropriately in the terminal box with screws.



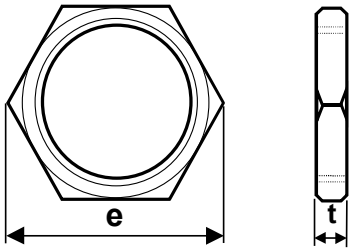
When a hole once made is not used, purchase the following rubber bushing and mount it at the hole.

Model	Ordering number
β3/10000*i* to β12/7000*i*	A06B-0754-K001

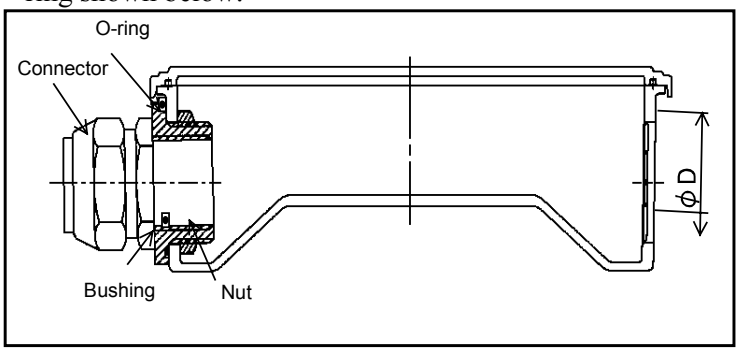
*1 The nut used to fasten the connector to the terminal box must be smaller than the size listed below. (Any larger nut interferes with the terminal box.) For the diameter of the cable hole in each model, refer to the outside dimension drawing of the respective models.

Cable hole diameter	Outside diameter e	Width t
ϕ42.5 mm	53 mm (maximum)	9 mm (maximum)

Outside dimensions of the conduit-connector retaining nut



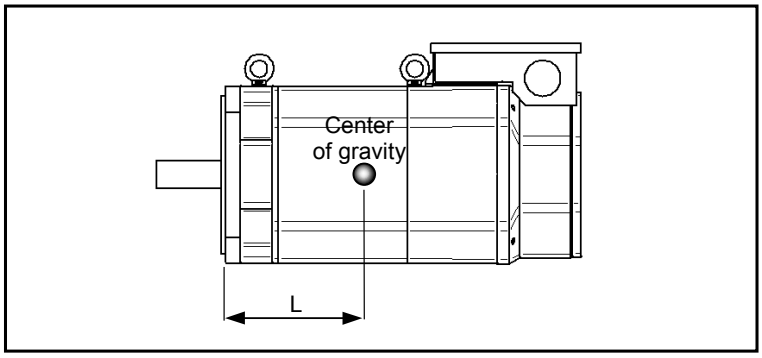
*2 If the connector you want to use is smaller than the cable hole on the terminal box, prepare the bushing, nut, and O-ring shown below.



Cable hole diameter ϕD	O-ring code	
	JIS B 2401	ISO 3601-1
ϕ42.5 mm	P46	C0462G

4 Center of gravity

The distance L from the flange end face to the center of gravity in each model is listed below.



β*i* series	**Center of gravity [mm]**
β3/10000*i*	125±5
β6/10000*i*	170±5
β8/8000*i*	150±5
β12/7000*i*	185±5

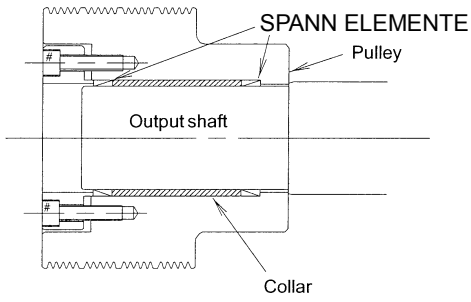
2.2 WHEN A MOTOR IS CONNECTED TO A SPINDLE VIA A BELT

⚠ CAUTION

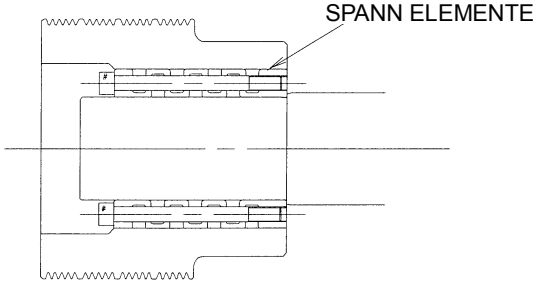
1 Mounting the pulley
- The gap between the inner surface of the motor pulley and output shaft should be 10μm to 15μm.
- If the gap is large when the high-speed rotation (4500 min^{-1}), fretting produced at the gap causes a large vibration, resulting in damage to the motor bearing.
- As the vibration is intensified, fretting occurs in the gap mentioned above, and the pulley and shaft can stick to each other.
- To secure a pulley, use a friction-tightening part such as a SPANN ELEMENTE or clamping sleeve.

NOTE
The SPANN ELEMENTE RfN8006 is manufactured by RINGFEDER.
The clamping sleeve DSM is manufactured by SPIETH.

Example 1 Two sets of SPANN ELEMENTE RfN8006 are used.
The collar is pinched at two points by the two sets.



Example 2 Clamping sleeve DSM is used.

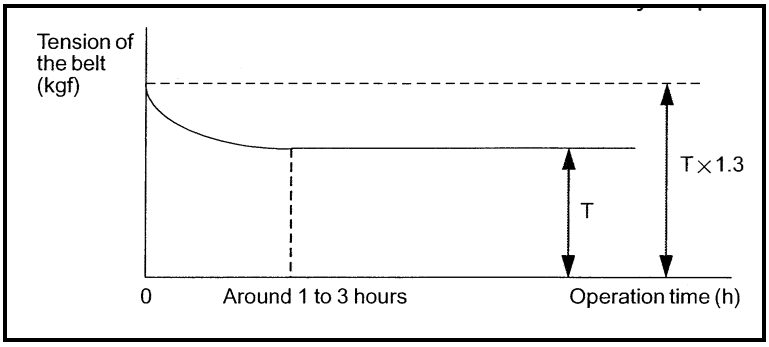


2 After attaching a pulley to the motor, adjust the vibration of the belt groove to within 20 μm (T.I.R).

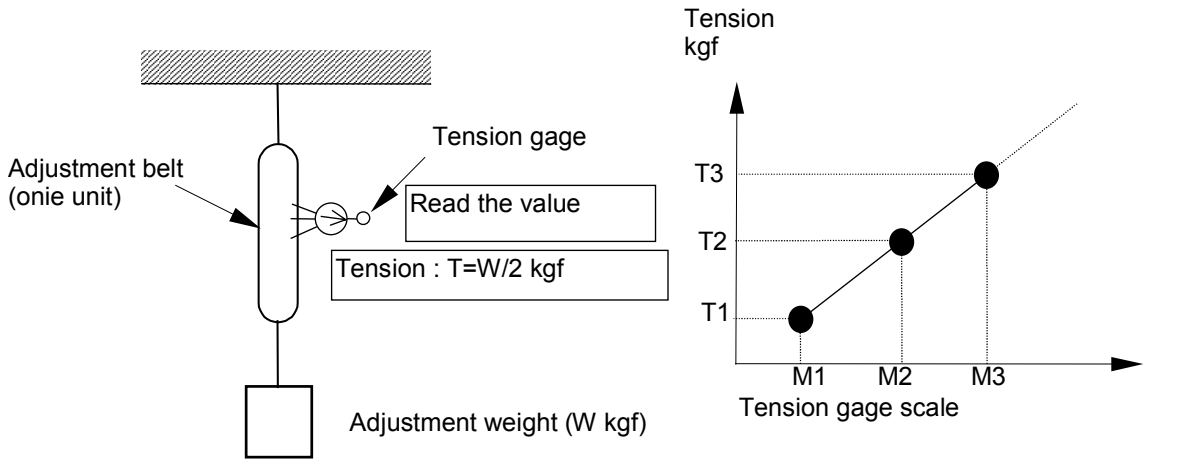
3 Before the belt is looped, FANUC recommends that the dynamic balance (field balance) be corrected.

4 Limit the radial load applied to the motor output shaft by the tension of the belt to the allowable value described in the manual for each series. If the allowable value is exceeded, the bearing or shaft may fail prematurely.

5 The tension of the belt is reduced as a result of abrasion during the initial several hours of operation. To transfer torque normally after this reduction in tension, the initial tension before operation should be set to a value 1.3 times the actually required tension T.

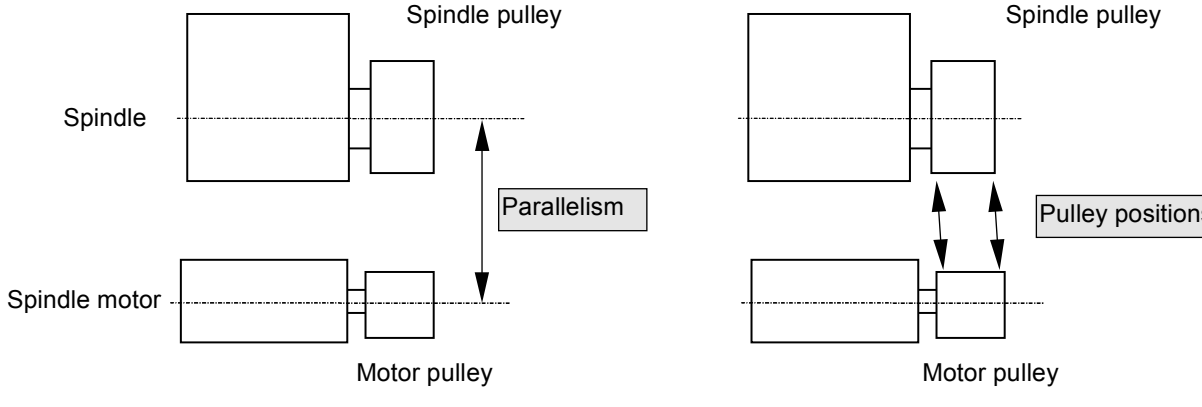


6 Use an appropriate tension gage to tension the belt.
Examples
Sonic type:
U-305 series manufactured by UNITTA.
Mechanical type:
BT-33-73F manufactured by KENT-MOORE of the United States
A mechanical type tension gage may give a false reading depending on the belt's number of peaks and length. To overcome this problem, hang an object of a known weight on the belt, read the tension value, then adjust the tension gage.



Radial load applied to the motor shaft (kgf) = tension (T kgf) × 2 × number of belts

7 Reduce the deviation between the positions of the motor and machine pulleys in the shaft direction as much as possible and ensure that the center lines of the shafts are as parallel as possible.



8 Since β*i* series motors are more compact than α*i* series motors even though both have the same power output, the allowable radial load of the β*i* series is smaller. Therefore, it is necessary to prevent the allowable radial load of the motor from being exceeded by using a belt that has stable transmission characteristic even at a high speed and designing the pulley with a large diameter. For the allowable radial load for each model, see Chapter II.5.

Recommended belt:

Banfle scrum belt or Banflex belt manufactured by Bando Chemical Industries Ltd (belt speeds of up to 60 m/s).

Example of belt design

Design must be made so that the static axial load by a belt that was subject to initial wear does not exceed the allowable radial load for each model. (A new belt is subject to initial wear after several hours operation and the static axial load becomes equal to that for the restretched belt in the following table.)

Motor model		β3/10000*i*	β6/10000*i*	β8/8000*i*	β12/7000*i*
Designed power (15 min. rated output × 1.1)	[kW]	6.1	8.3	12.1	16.5
Belt type		5M (5MS)	5M (5MS)	5M (5MS)	7M (7MS)
Pulley dia. on the spindle side (PCD)	[mm]	φ165	φ165	φ210	φ210
Pulley dia. on the motor side (PCD)	[mm]	φ132	φ132	φ168	φ168
Gear reduction ratio		0.80	0.80	0.80	0.80
Motor max. speed	[min^{-1}]	8,000	8,000	6,000	6,000
Belt surface speed (at the max. motor speed)	[m/s]	55.3	55.3	52.8	52.8
Number of belt crests		4	6	7	4
Static axial load for new belts	[N]	1,200	1,638	1,904	2,604
Static axial load for re-stretched belts	[N]	923	1,260	1,464	2,003
Allowable radial load (at the output axis center)	[N]	999	1,607	2,205	3,371

NOTE

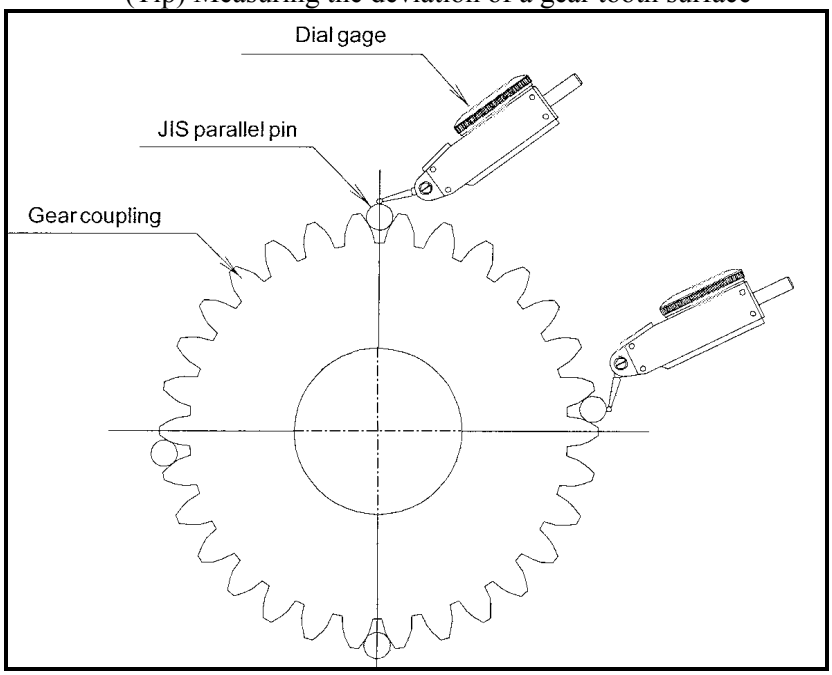
1 Prevent oil or dust from entering between the belt and the pulley. Otherwise, the belt may slip.
2 If the allowable radial load is exceeded, reduce the load by using support bearings on the machine side or directly connecting to the machine in order to secure reliability for a extended period of time.

2.3 WHEN A MOTOR IS CONNECTED TO A SPINDLE VIA A GEAR

⚠ CAUTION

1 Do not use a helical gear which applies a load in the motor axial direction.

2 To prevent unusual gear sounds, apply the following precautions:
(1) The deviation of the gear tooth surface should indicate the proper value.
(Tip) Measuring the deviation of a gear tooth surface



(2) The correct backlash should be provided.
(3) The perpendicularity of the motor flange mounting surface to the machine shaft should indicate the proper value.

3 Mount the motor on the machine so that the vibration acceleration is 0.5 G or less when it is measured using the method described in CAUTION 5 of Section 2.1.

2.4 WHEN A MOTOR IS DIRECTLY CONNECTED TO A SPINDLE VIA A COUPLING

⚠ CAUTION

1 Use a coupling which can absorb thermal expansion in the axial direction of the motor mating shaft so that no load is applied in the motor axial direction.
(Examples)
- Diaphragm coupling (EAGLE INDUSTRY CO., LTD.)
- Oldham's coupling
- Gear coupling

2 Set the torsional rigidity of the coupling to an appropriate high value. If the torsional rigidity is low, vibration may be produced during orientation.

3 It is important to perform centering and obtain parallelism to avoid having to recourse to the flexibility of the coupling.
At high speeds, any eccentricity may cause the bearing to fail prematurely.

4 Check all machines before shipping to confirm that the vibration acceleration is 0.5 G or less when measured using the method described in CAUTION 5 of Section 2.1.

3 NOTES ON OPERATION

⚠ WARNING

1 When supplying voltage to the spindle motor or the fan motor, ensure that the earth cable is connected to the earth terminal and secure that the spindle motor is put to earth certainly.

⚠ CAUTION

1 Sound and vibration
Check that there is no abnormal sound or vibration.

2 Cooling
Clean off dust from the cooling air inlet and outlet of the stator every year, and check the flow of air carefully.

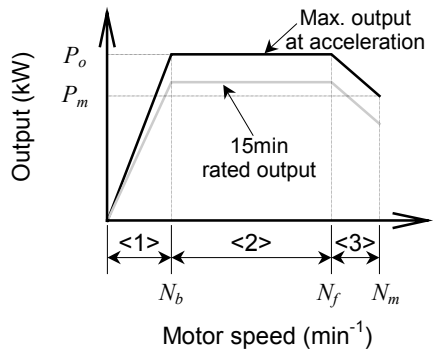
NOTE

1 To increase the operating lifetime of a motor of these series, break in the motor. As a guideline, increase the speed of the motor from 1000 min^{-1} to its maximum speed in 1000 min^{-1} increments, and operate the motor at each speed for about 5 minutes.

4 DETERMINING THE ACCELERATION TIME

Estimated output during acceleration is the 15 minutes rated output for each model multiplied by 1.1.

The time required for each acceleration for the acceleration/ deceleration output characteristics shown below can be obtained from the following equation.
Since machine load torque is not taken into consideration, the actual time is slightly longer than the calculated time.



J_L	:Load inertia converted for the motor shaft [kgm^2]
J_m	: Motor inertia [kgm^2]
P_o, P_m	:Output [kW]
N_b, N_f, N_m	:Motor speed [min^{-1}]

<1> Acceleration time (t_1) in the constant-torque range (0 to N_b)

$$t_1 = 0.01097 \frac{(J_L + J_m) \cdot N_b{}^2}{P_o \cdot 1000} [\text{sec}]$$

<2> Acceleration time (t_2) in the constant-output range (N_b to N_f)

$$t_2 = 0.01097 \frac{(J_L + J_m) \cdot (N_f{}^2 - N_b{}^2)}{2 \cdot P_o \cdot 1000} [\text{sec}]$$

<3> Acceleration time (t_3) in the decreasing-output range (N_f to N_m)

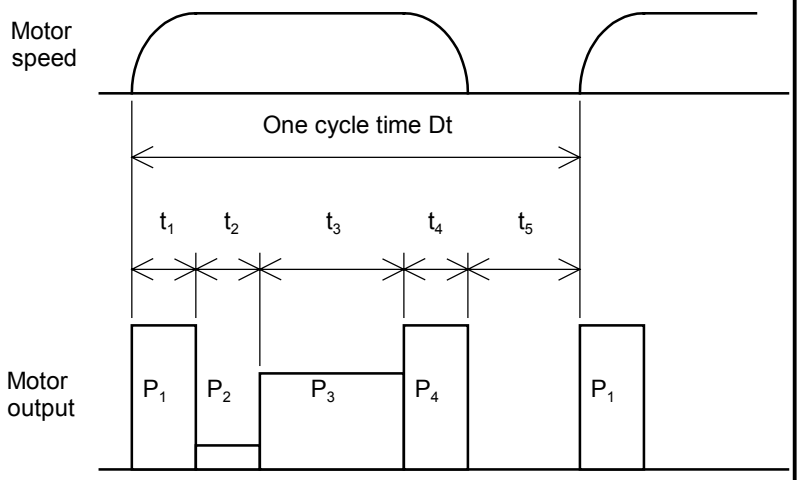
$$t_3 = 0.01097 \frac{(J_L + J_m) \cdot (N_m - N_f) \left\{ (N_m - N_f) - \frac{P_o \cdot N_m - P_m \cdot N_f}{P_m - P_o} \cdot \ln \frac{P_m}{P_o} \right\}}{(P_m - P_o) \cdot 1000} [\text{sec}]$$

The total time (t) required for acceleration in the range from 0 to N_m is $t_1+t_2+t_3$ [sec]

5 DETERMINING THE ALLOWABLE DUTY CYCLE

When machining requires the spindle to accelerate and decelerate frequently, the average output per cycle must not exceed the continuous rated output. The allowable duty cycle for a typical AC spindle motor can be obtained as shown below.

Duty cycle and average output



P_1, P_4 : Acceleration/deceleration output [kW]
= 15 min rated output at const. output power range × 1.1
Note 1) This is not a guaranteed value but a guideline.
P_2 : Output with no load [kW] (P_2=0)
P_3 : Cutting output [kW]

$$\text{Average output} \quad Pav = \sqrt{\frac{P_1^2 t_1 + P_2^2 t_2 + P_3^2 t_3 + P_4^2 t_4}{Dt}}$$

NOTE This is not a guaranteed value but a guideline.

NOTE
1 Cutting output P_3 at motor speed N which is lower than base speed Nb shall be calculated by the following equation.
$P_3=P_C \times Nb/N$ [kW] (P_C: Actual cutting output)
2 In case that P_3 is calculated by the load indicator voltage, use the following equation.
$P_3=P_1 \times L_3/10$ [kW]
(L_3: Load indicator voltage in cutting [V])

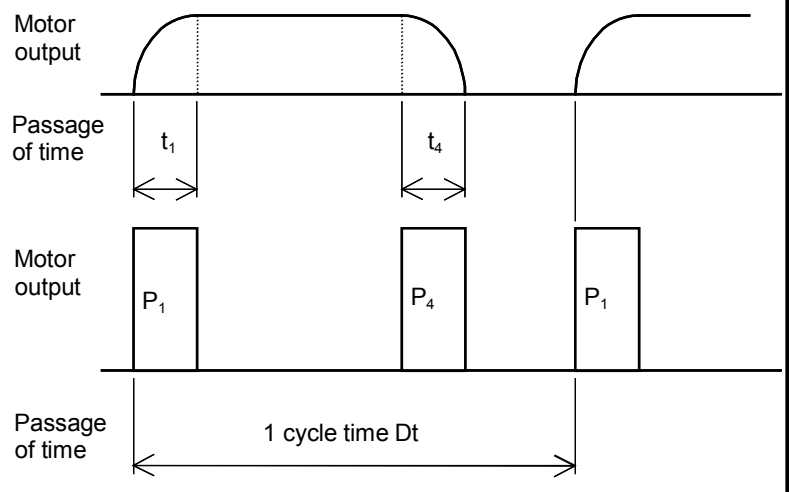
Allowable duty cycle time Dt

From the equation for getting the value of Pav[kW].

$$Dt=\frac{1}{Pav^2}\times(P_1^2t_1+P_2^2t_2+P_3^2t_3+P_4^2t_4)$$

Substitute the continuous rated output of the used AC spindle motor for Pav [kW] in the equation above.

Allowable duty cycle time Dt for repeated acceleration/deceleration



$$Dt=\frac{1}{P_{CONT}^2}\times(P_{15min}^2\times1.1^2)\times(t_1+t_4)$$

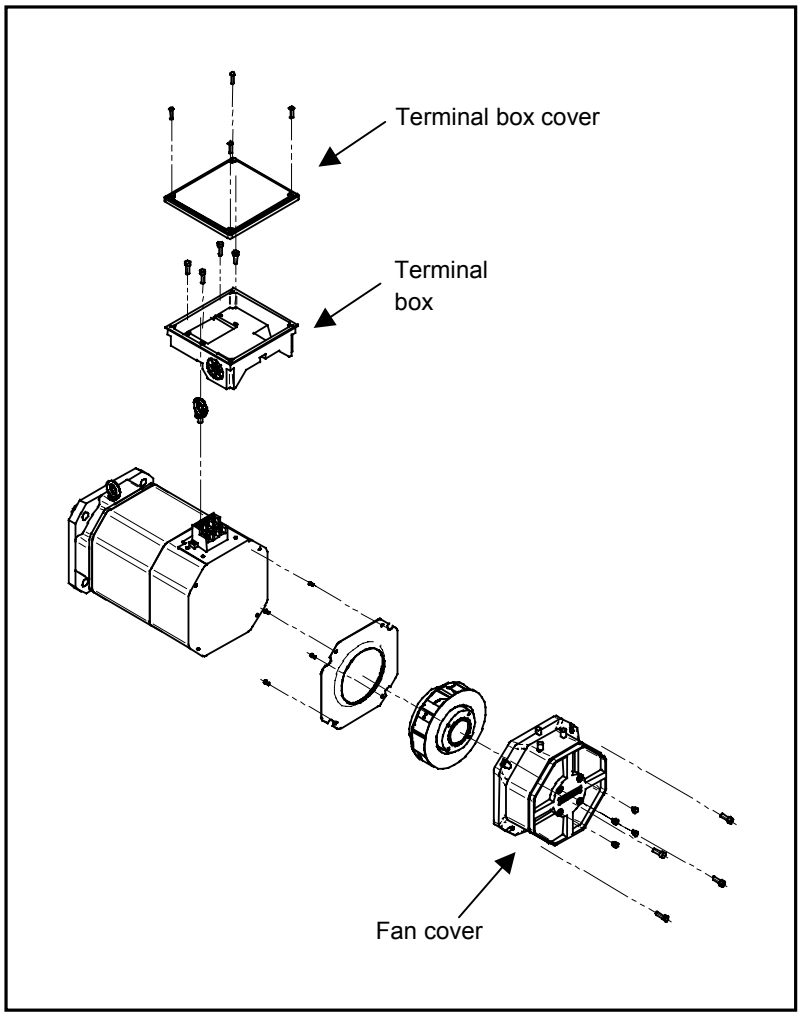
P_{cont} : Continuous rated output
P_{15min} : 15-minute rated output
t_1+t_4 : Sum of the acceleration and deceleration time

6 DISPOSAL OF SPINDLE MOTORS BY MATERIAL TYPE

Disposal of motors by separating plastic parts from metal parts

After a motor is dismantled, the plastic parts (terminal box, terminal box cover, fan cover) must be separated for disposal. The plastic parts are made of the following material.

Plastic material : >(PBT+PC)-GF(30)FR(17)<



II. FANUC AC SPINDLE MOTOR βi SERIES

1 GENERAL

The FANUC AC SPINDLE MOTOR βi series is a highly cost-effective series having sufficient basic performance as the core machine tool.

Features

- High-output and high-torque are implemented defying its compact body.
- Spindle HRV control enables high-efficiency and low-heating driving.
- The built-in M*i* sensor or MZ*i* sensor enables synchronous spindle and Z-axis feed and rigid tapping.
- Improvement in machining of the motor housing enhances the accuracy of the mounting part.
- Waterproof and pressure-proof design conforming to the international standard (IEC) is employed to improve reliability and make it resistant to most environments.

2 SPECIFICATIONS

Series			βi series			
Item \ Model			β3/10000*i*	β6/10000*i*	β8/8000*i*	β12/7000*i*
Rated output (*1)	Cont., 60 min rated S3 40% (*2)	kW (HP)	3.7 (5.0)	5.5 (7.4)	7.5 (10)	11 (14.7)
	15 min rated, S3 25% (*2)	kW (HP)	5.5 (7.4)	7.5 (10)	11 (14.7)	15 (20.1)
Rated current A (*3)	Cont. rated		18	40	36	43
	60 min, S3 40% rated (*2)		22	47	42	49
	15min, S3 25% rated (*2)		29	56	56	63
Speed min^{-1}	Base speed	Cont. rated	2000	2000	2000	2000
		Short time rated	1500	1500	1500	1500
	Max. speed		10000	10000	8000	7000
Cont. rated torque at const. rated torque range		N·m (kgf·cm)	17.7 (180)	26.3 (268)	35.8 (365)	52.5 (536)
Rotor inertia	$kg·m^2$		0.0078	0.0148	0.0179	0.0275
	$kgf·cm·s^2$		0.08	0.15	0.18	0.28
Weight		kgf	27	46	51	80
Vibration			V5			
Noise			75dB(A) or less			
Cooling sysytem (*4)			Totally enclosed and fan cooled IC0A6			
Cooling fan		W	17		20	
Installation (*5)			Mount the motor so that the output shaft points in a direction ranging within 45° degrees above the horizontal to vertically downwards. IMB5,IMV1,IMB3,IMB6,IMB7,IMB8,IMV5			
Allowable overload capacity (1 min) (*6)			110% of 15 min rated output			
Insulation			Class H			
Ambient temperature			0 to 40°C			
Altitude			Height above sea level not exceeding 1000m			
Painting color			Munsell system N2.5			
Sensor			Mi sensor or MZi sensor			
Type of thermal protection (*7)			TP211			
Resolution of the MZi sensor		/rev.	2048		4096	
Number of detected gear teeth per rotation λ/rev.			128		256	
Bearing lubrication			Grease			
Maximum output during acceleration(*8) kW			6.1	8.3	12.1	16.5
Applicable spindle amplifier module			SVPM2-5.5*i*	SVPM2-11*i*		SVPM2-15*i*
			SVPM3-5.5*i*	SVPM3-11*i*		SVPM3-15*i*
Model			β3/10000*i*	β6/10000*i*	β8/8000*i*	β12/7000*i*

(*1) The rated output is guaranteed at the rated voltage.
(Amplifier input: 200/220/230VAC +10% -15%, 50/60 Hz ±1Hz)
If the input voltage fluctuates, it is possible that the rated output cannot be obtained even when such fluctuations are within the allowable fluctuation range.
(*2) The cycle time is 10 minutes, S3 40%: ON 4 minutes, OFF 6 minutes, and S3 25%: ON 2.5 minutes, OFF 7.5 minutes.
(*3) The rated current is not a guaranteed value but a guideline for the maximum current at rated output.
(*4) IC code conforms to IEC 34-6.
(*5) IM code conforms to IEC 34-7.
(*6) This is not a guaranteed value but a guideline for the maximum motor output at a rated supply voltage. 110 % of 15 min rated for β3/10000*i*, β6/10000*i*, β8/8000*i*, β12/7000*i*.
(*7) Type conforms to IEC 34-11.
(*8) This is not a guaranteed value.
(*9) Degree of protection:
with oil seal: IP54, without oil seal: IP40.

3 OUTPUT/TORQUE CHARACTERISTICS

Reference
Calculation for torque

Torque T can be obtained by the following equation.

$T[N \cdot m]=P[kW] \times 1000/0.1047/N[min^{-1}]$

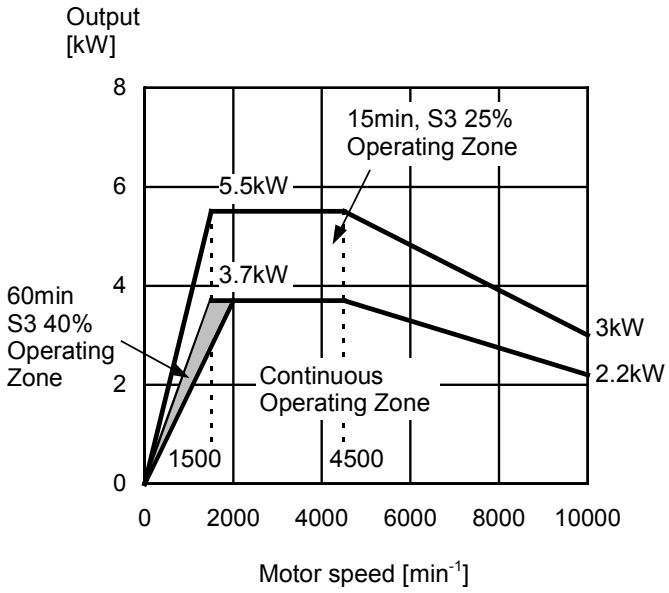
P[kW]: Motor output

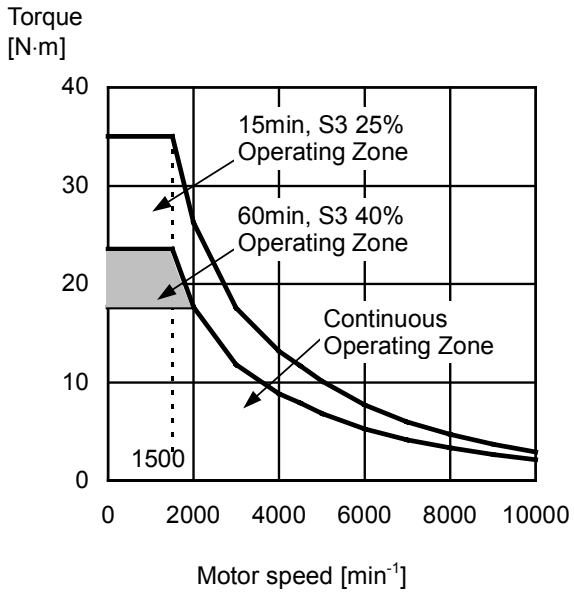
$N[min^{-1}]$: Motor speed

When the unit of T is [kgf·m],

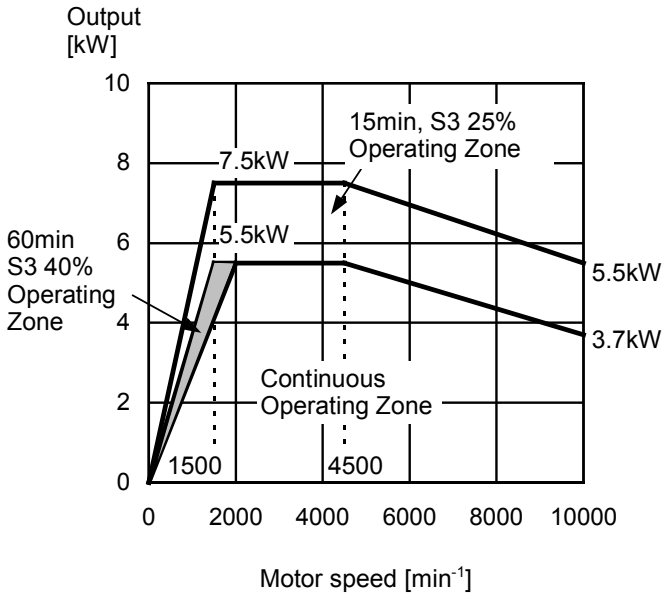
$T[kgf \cdot m]=P[kW] \times 1000/1.0269/N[min^{-1}]$

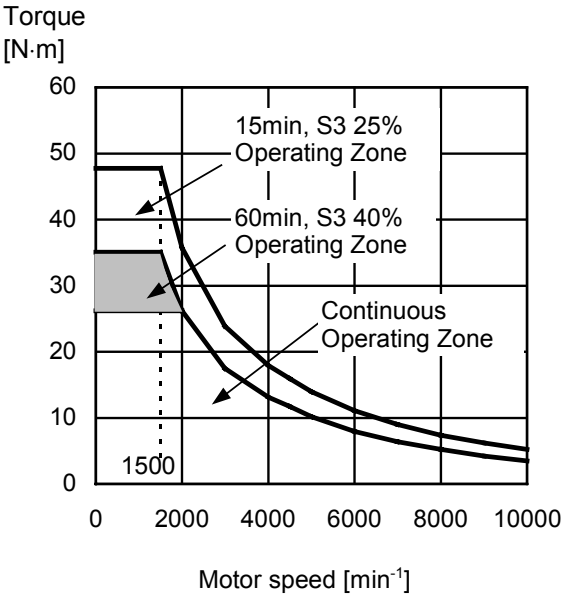
3.1 MODEL β3/10000*i*



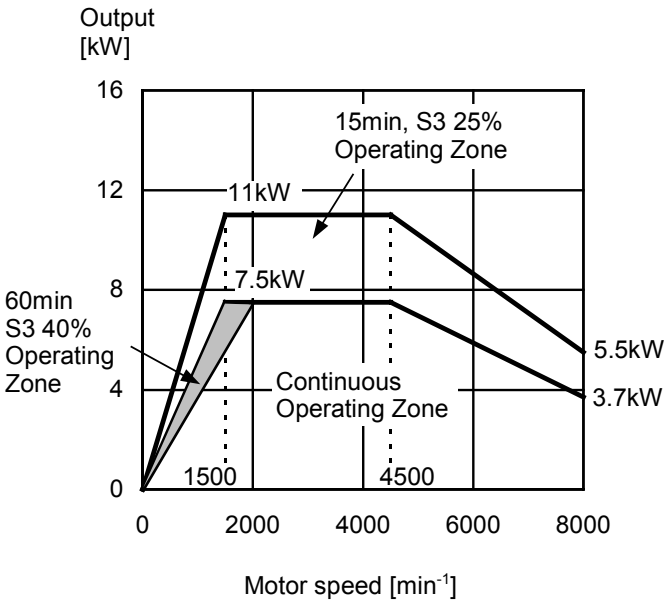


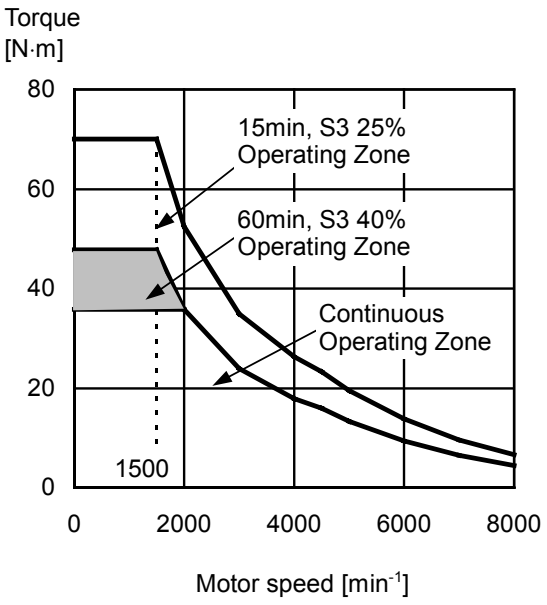
3.2 MODEL β6/10000*i*



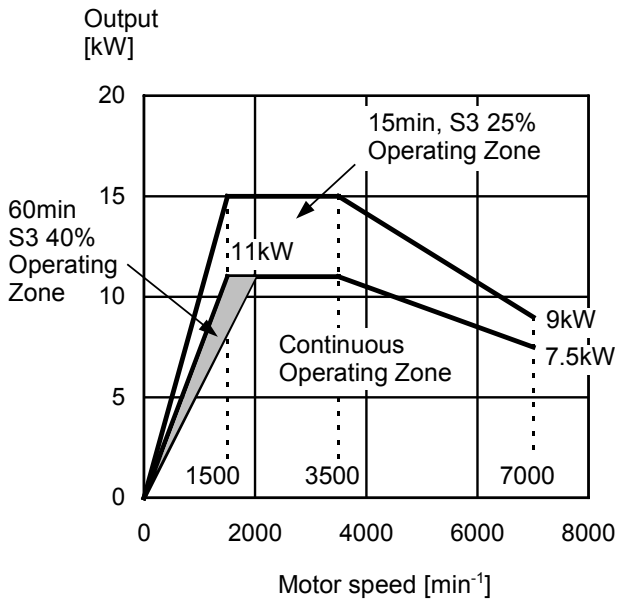


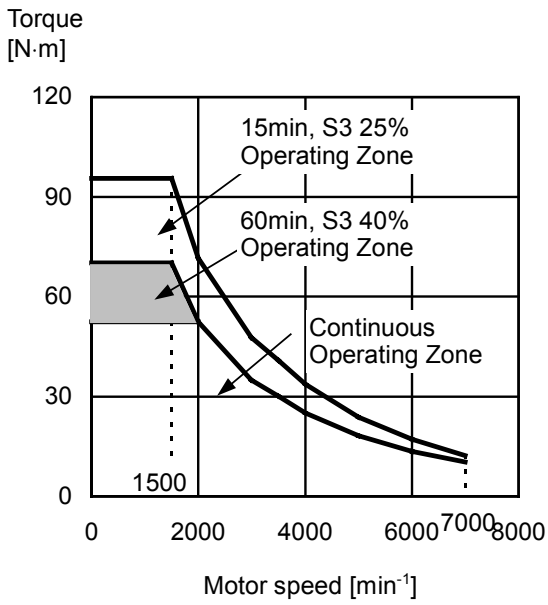
3.3 MODEL β8/8000*i*





3.4 MODEL β12/7000*i*





4 CONNECTIONS

4.1 POWER LEAD CONNECTION

⚠ WARNING

To attach the power leads, follow the procedure described in this section to make connections with specified torque. Driving a motor with terminals loosened could result in the terminal board overheating and causing a fire. In addition, it may remove terminal to cause a ground fault, short circuit, or electric shock.

⚠ CAUTION

1. When attaching the power leads to the terminal board of a motor, tighten the screws with torque specified in the table.

Terminal size	Tightening torque [N·m]
M4	1.1 to 1.5
M5	2.0 to 2.5

2. To maintain the required isolation distance, observe the following:
   - When attaching a crimp terminal at the end of a power lead, cover the crimped portion of the crimp terminal with insulating tube.

4.2 CONNECTION OF POWER LEAD AND FAN MOTOR CABLE

Cables for power lead and fan motor are connected to the terminal block.

Size of screws used in the terminal block / Model	Power lead	Fan motor
	U,V,W,G	FMU,FMV,FMW
β3/10000*i* to β12/10000*i*	M5	Screw-less terminal block

Cable for the power lead

The power lead used between the amplifier and the motor must be one of the following or their equivalents.

Motor model	Applicable wire size (mm^2)
	(*1) LMFC
β3/10000*i*	$3.5mm^2$
β6/10000*i*	$5.5mm^2$
β8/8000*i*	$5.5mm^2$
β12/7000*i*	$8mm^2$

NOTE
*1 LMFC wire: Fire-retardant polyflex wire (heat-resistant 105°C)

Current value of FAN MOTOR

βi series spindle motor models	50Hz			60Hz		
	Rated voltage [V]	Rated current [A]	Surge current [Ap-p]	Rated voltage [V]	Rated current [A]	Surge current [Ap-p]
β3/10000*i*, β6/10000*i*	200	0.10	0.41	200	0.10	0.40
β8/8000*i*, β12/7000*i*	200	0.13	0.50	200	0.14	0.51

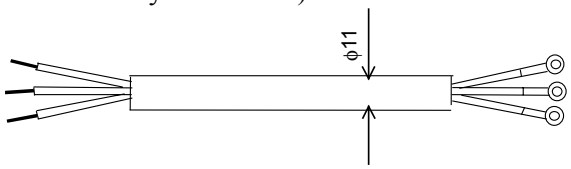
NOTE
1 The term "surge current" represents a peak-to-peak current that flows when the power is turned on.
2 The values are a rough standard. They are not guaranteed.

Cable for the fan motor

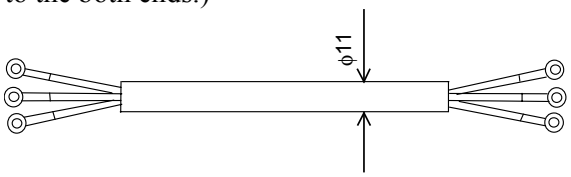
The machine tool builder is to prepare the following cable for the fan motor:

Vinyl heavy-duty power cord JIS C 3312 3-conductor
Conductor: 37/0.26 (2 mm^2)
Sheath: PVCϕ11
Crimp terminal: T2-4S

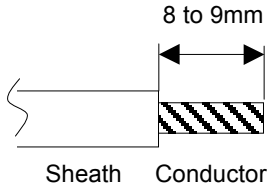
<1> For a non-screw terminal block (Peel off each wire sheath on the motor side by 8 to 9 mm.)



<2> For an M4 or M3.5 screw terminal block (Attach crimp terminals to the both ends.)



Method of connection to a non-screw terminal for the fan motor

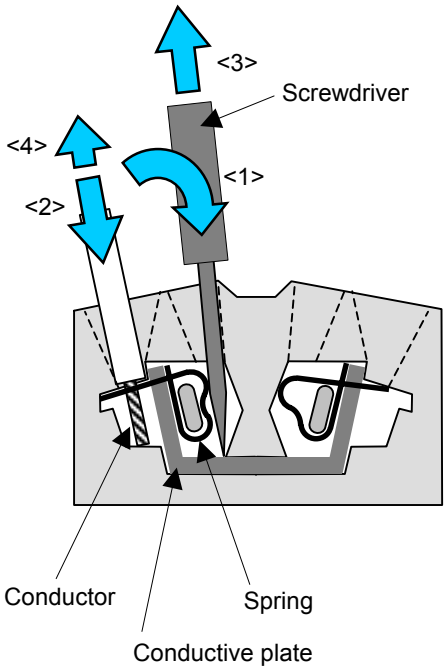


Peel-off length of a wire sheath

By using an appropriate tool, peel off each wire sheath by 8 to 9 mm.

Screwdriver

Use a flat-blade screwdriver with a blade size of 3.5 × 0.5 mm. (210-120J (standard type), 210-350J (short type) manufactured by WAGO)



Connection procedure

<1> Insert the tip of the screwdriver into the screwdriver insertion slot (small rectangular hole) until the tip touches the spring. Next, while tilting the screwdriver toward the inside of the terminal block, push the screwdriver until it butts the conductive plate. In this state, the spring is opened completely, and the screwdriver is held in the terminal block. Ensure that the screwdriver is secured. Otherwise, the next step (wire insertion) cannot be conducted easily.

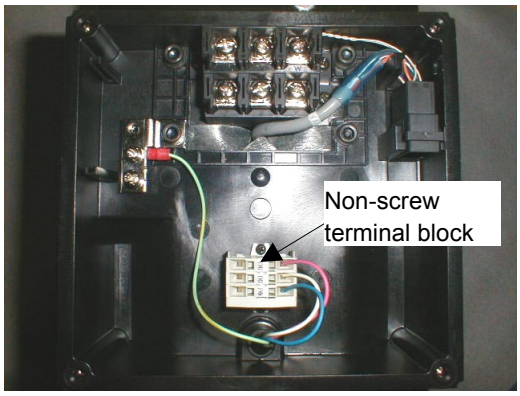
<2> Check the peel-off length (8 to 9 mm), then insert the wire into the wire insertion slot (large rectangular hole) until it stops, by sliding the wire along the outer side of the hole slowly so that the conductor does not become loose. Be careful not to push a thin wire excessively.

<3> While holding down the inserted wire by one hand, extract the screwdriver. The spring is closed to make a connection.

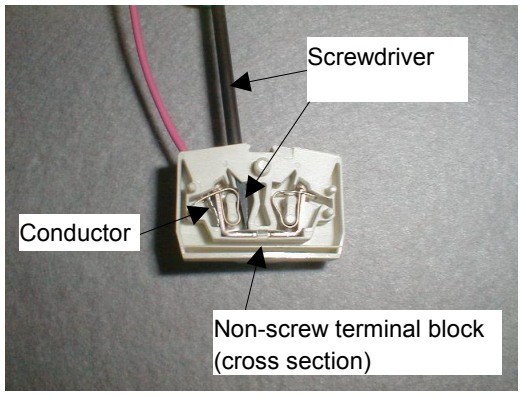
<4> By slightly pulling the wire, check that the wire is connected firmly. The wire need not be pulled intensely.

Cautions

- Only one wire must be connected to one spring.
- A wire, which may be a stranded wire or single conductor, can be directly connected without performing terminal processing if its sheath is peeled off. A wire after ferrule processing can also be connected.



Inside the terminal box

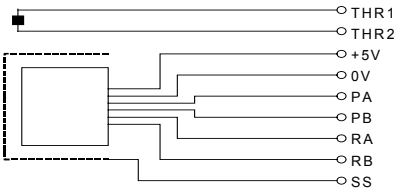


State of cable connection

4.3 CONNECTION OF SIGNAL LEAD

The connector manufactured by Tyco Electronics AMP is used for connection of M*i* sensor signals, MZ*i* sensor signals, and thermistor signals. The housing and contact of the connector are included in the terminal box.

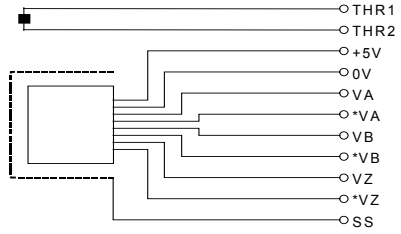
Connector attachment for a motor with a built-in M*i* sensor



Connector pins arrangement

Number	B1	B2	B3	B4	B5	B6
Color						
Signal		RA	RB		0V	THR2
Number	A1	A2	A3	A4	A5	A6
Color						
Signal	+5V	PA	PB		SS	THR1

Connector attachment for a motor with a built-in MZ*i* sensor



Connector pins arrangement

Number	B1	B2	B3	B4	B5	B6
Color						
Signal		*VA	*VB	*VZ	0V	THR2
Number	A1	A2	A3	A4	A5	A6
Color						
Signal	+5V	VA	VB	VZ	SS	THR1

- Connector housing and contact specifications

Connector and contact :
Tyco Electronics AMP specification D-3000 series

	Motor side		Cable side	
	FANUC specification	Manufacture specification	FANUC specification	Manufacture specification
Housing	A63L-0001-0535/121KDF	178964-6	A63L-0001-0460/121KD	178289-6
Contact	A63L-0001-0456/ASMT	175288-2	A63L-0001-0456/ASM	1-175217-2

Crimping tool : 91559-1 Extractor : 234168-1

- Thermistor specification

Signal THR1 corresponds to one of the thermistor terminals, and signal THR2, to the other terminal. The resistance of the thermistor is about 30 to 90 kΩ as measured at room temperature (20°C to 30°C).

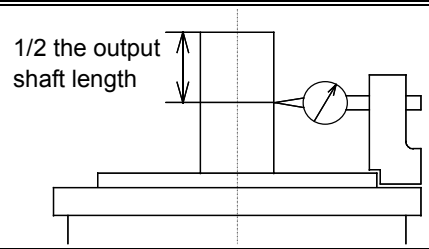
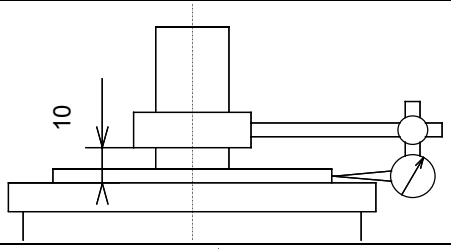
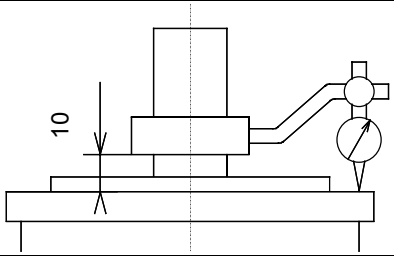
5 ALLOWABLE RADIAL LOAD

Use the motor output shaft below the allowable radial loads shown in the table below.

Model	Allowable radial load (kgf)	
	At output shaft end	At output shaft center
β3/10000*i*	882N (90kgf)	999N (102kgf)
β6/10000*i*	1470N (150kgf)	1607N (164kgf)
β8/8000*i*	1960N (200kgf)	2205N (225kgf)
β12/7000*i*	2940N (300kgf)	3371N (344kgf)

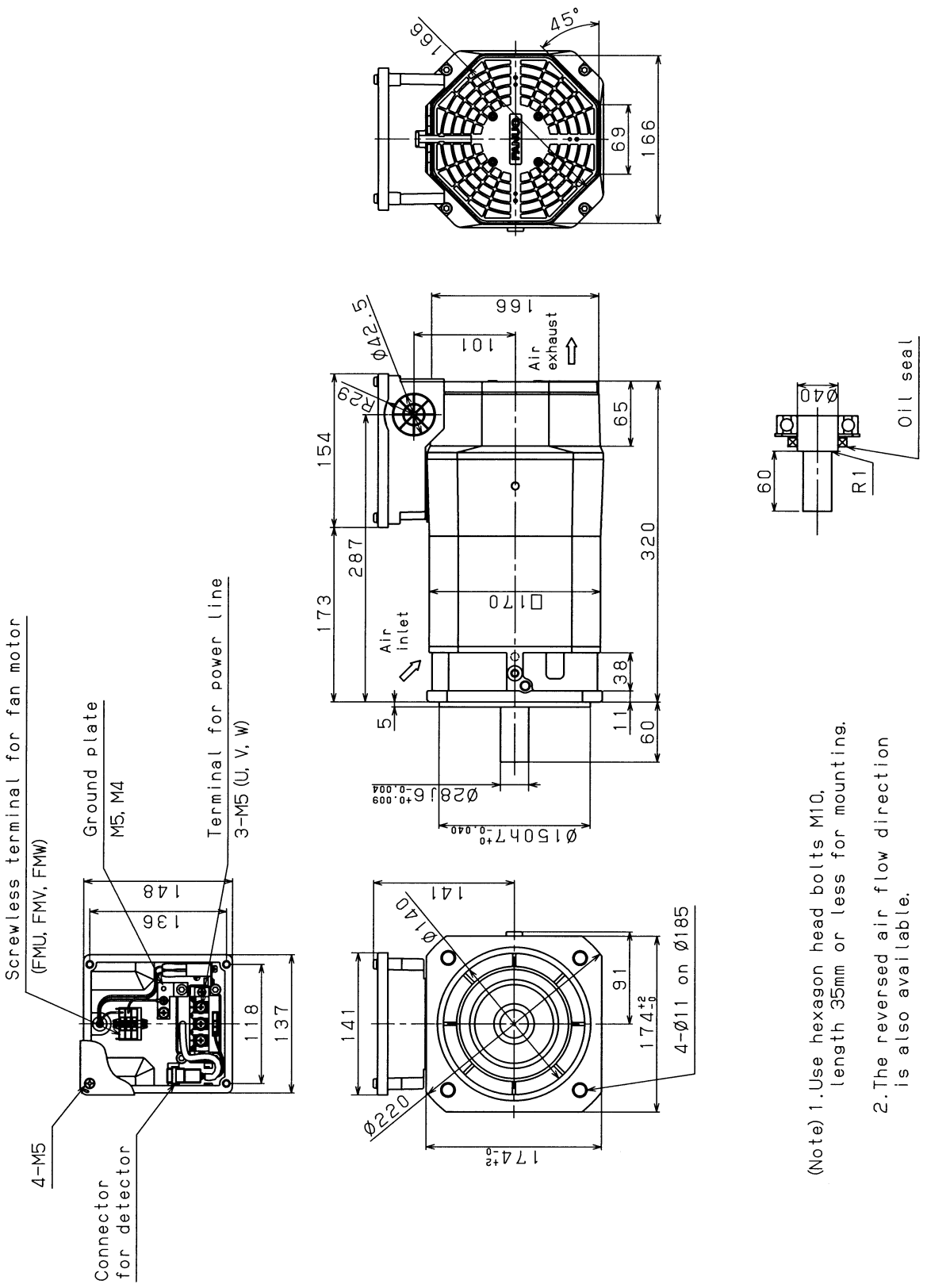
NOTE
1 When using a belt, adjust the tension so the allowable loads indicated above are not exceeded. If an excessive load is applied, consider the use of a support bearing on the machine side to maintain the long-term reliability of the motor. (If an excessive load is applied, it is possible that an abnormal sound may occur.)
2 When the belt tension is maximized at a point outside the output shaft end, the allowable loads are less than those at the output shaft end.
3 If a thrust load is applied when a helical gear is used, the shaft moves in the direction of the thrust. So, as a general rule, never apply a thrust load.

6 ASSEMBLING ACCURACY

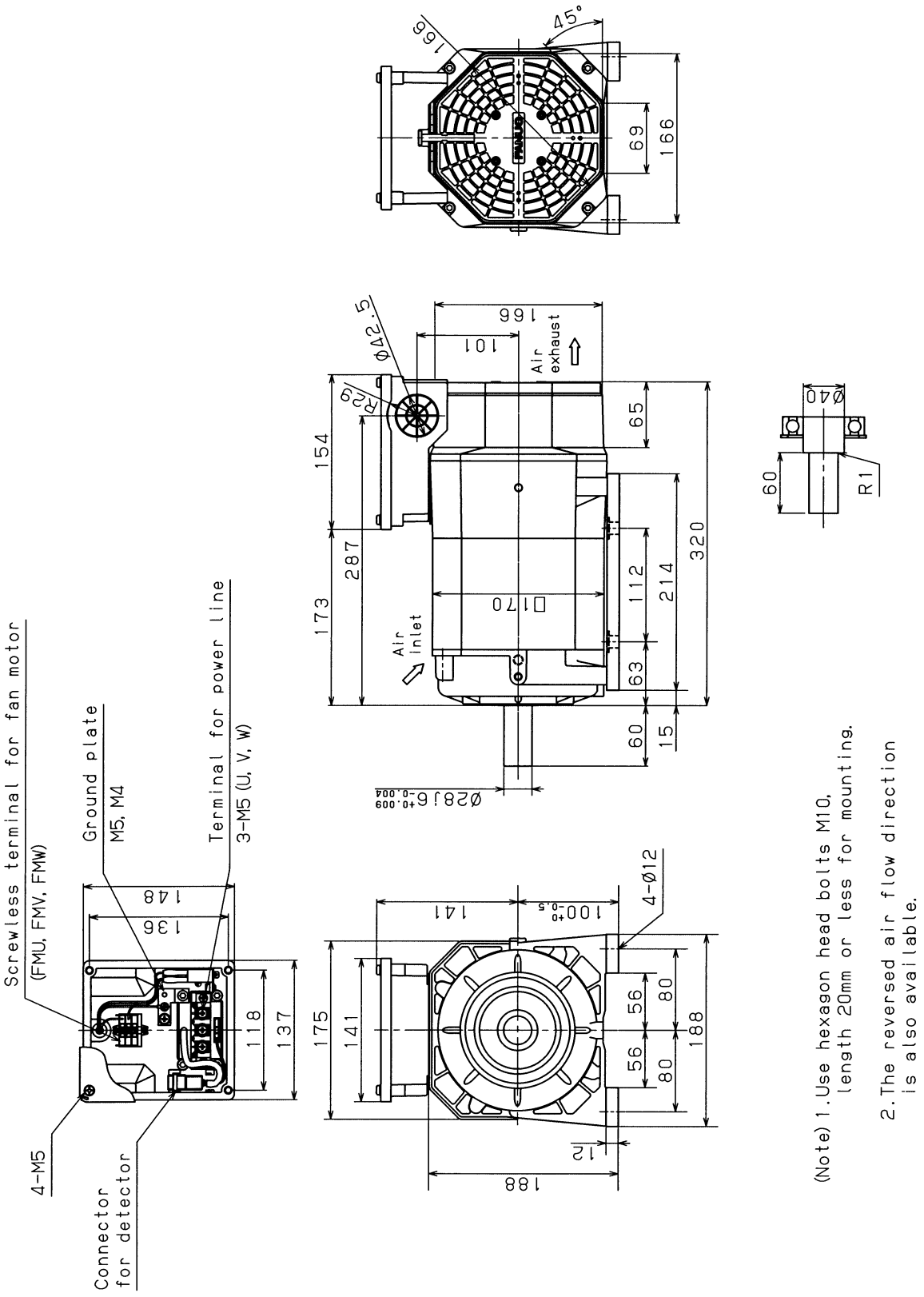
Item \ Model	β3/10000*i* to β12/7000*i*	Measuring method
Run-out at the end of the output shaft	20μm or less	
Run-out of the faucet joint for mounting the flange against the core of the shaft (only for flange type)	40μm or less	
Run-out of the flange mounting surface against the core of the shaft (only for flange type)	80μm or less	

7 EXTERNAL DIMENSIONS

7.1 MODEL β3/10000*i* (FLANGE MOUNTING TYPE)

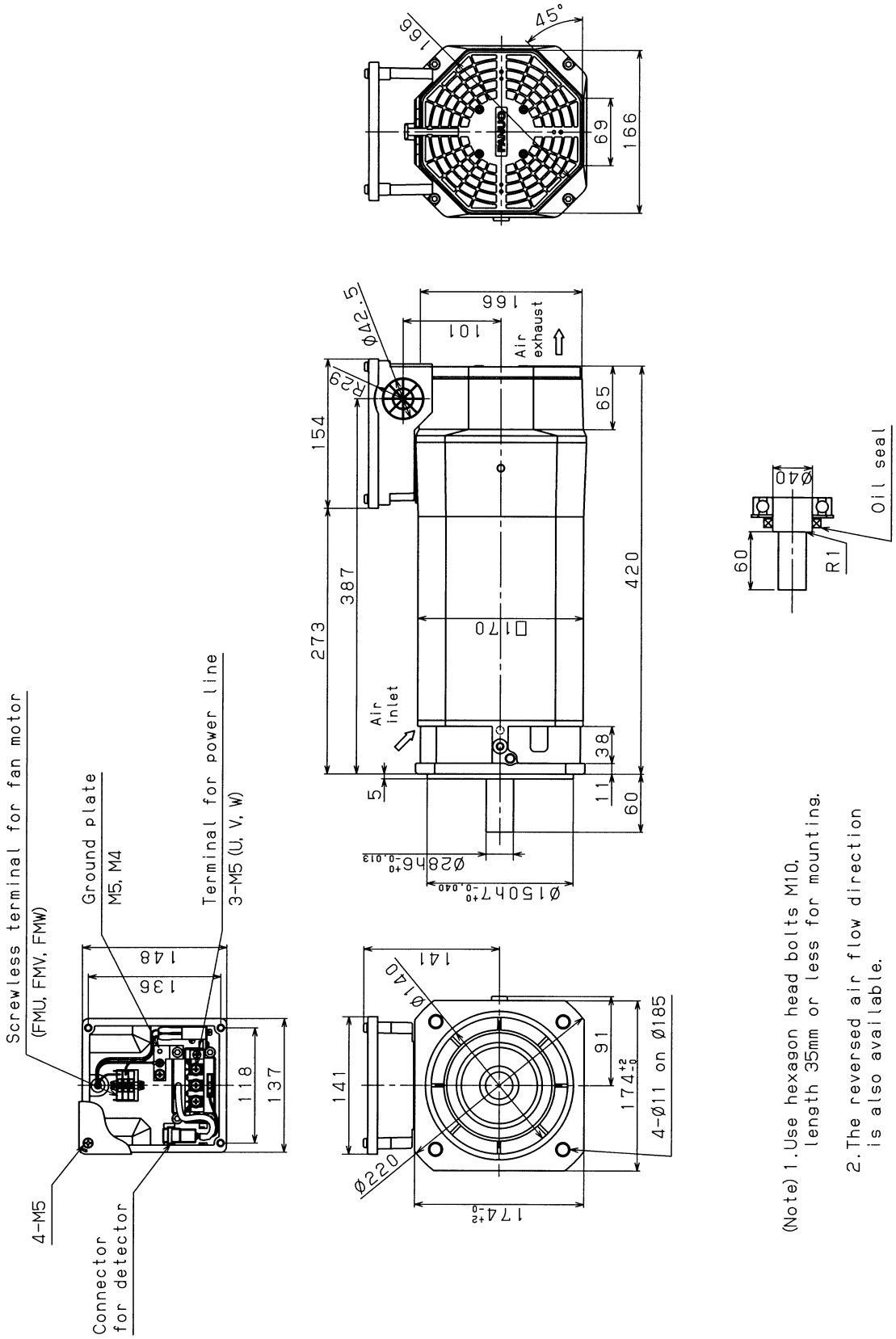


7.2 MODEL β3/10000*i* (FOOT MOUNTING TYPE)

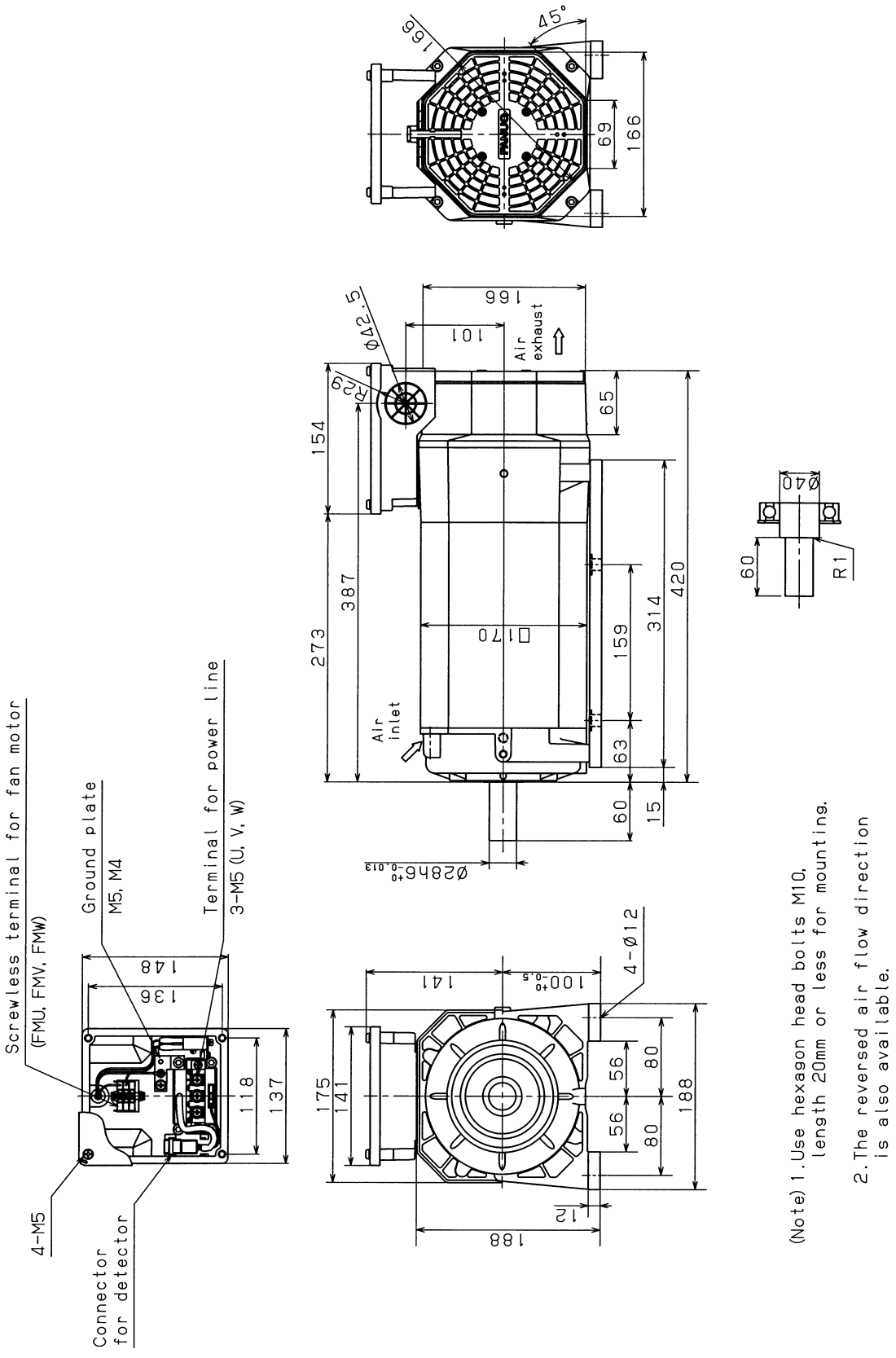


(Note) 1. Use hexagon head bolts M10, length 20mm or less for mounting.
2. The reversed air flow direction is also available.

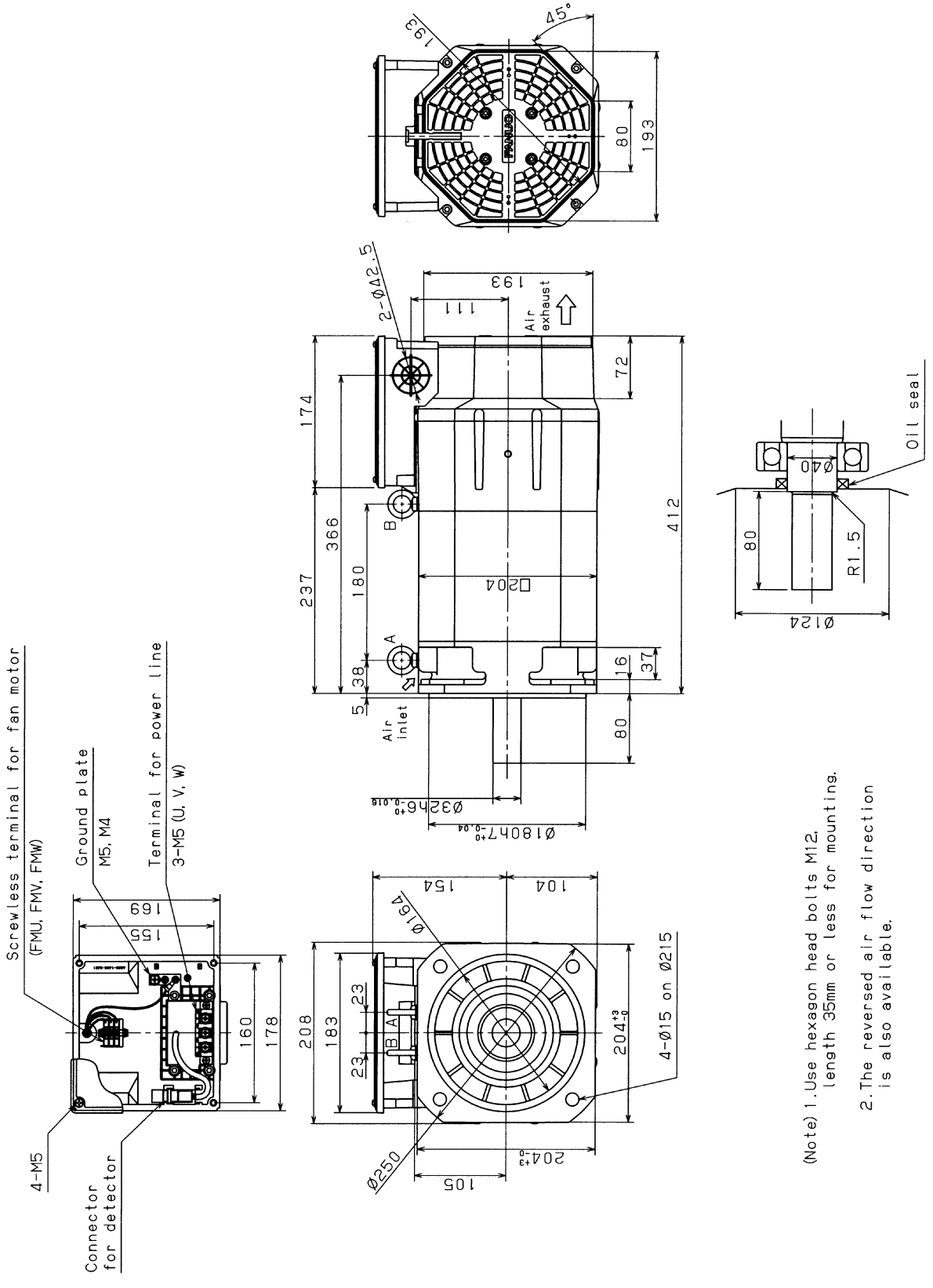
7.3 MODEL β6/10000*i* (FLANGE MOUNTING TYPE)



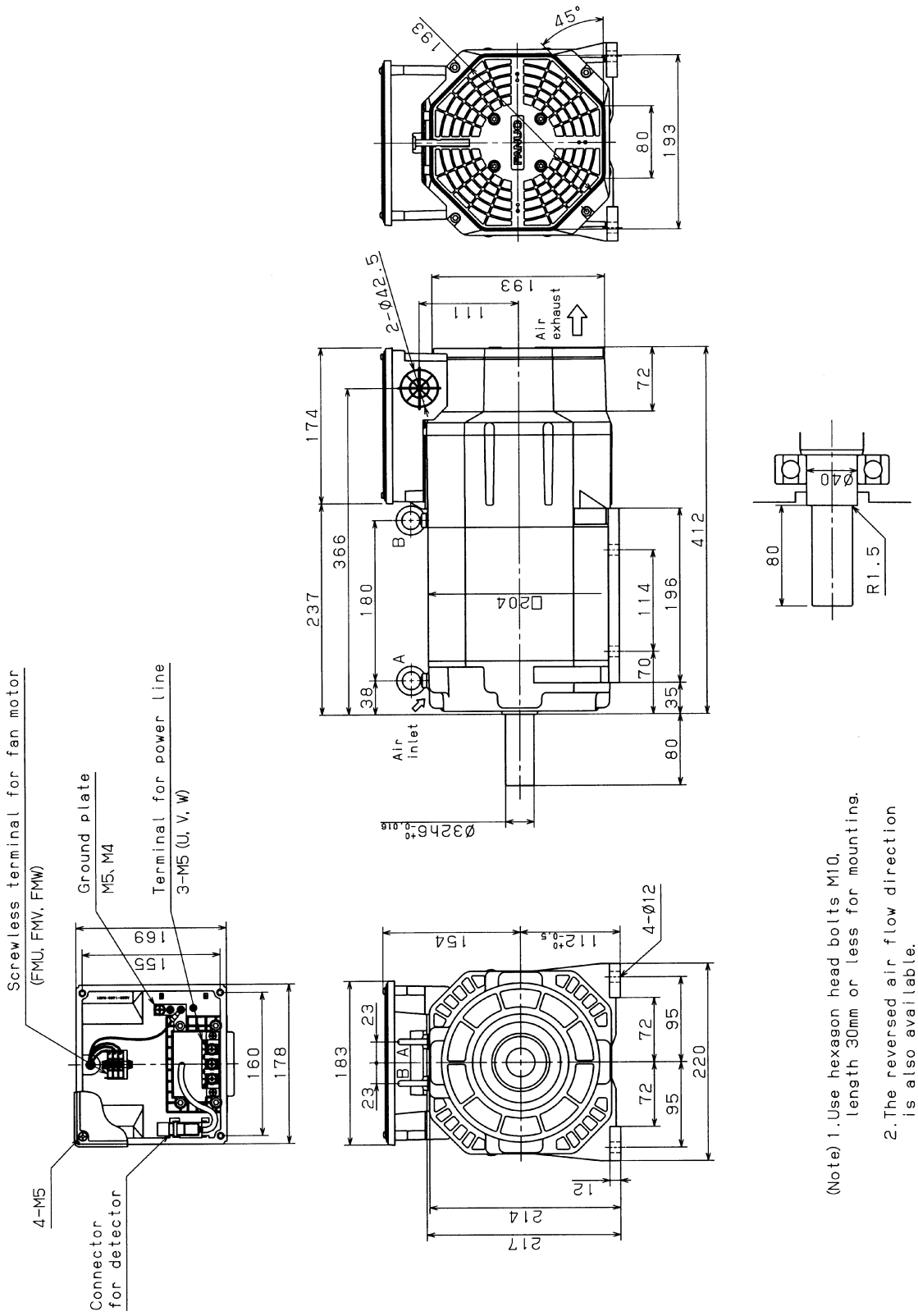
7.4 MODEL β6/10000*i* (FOOT MOUNTING TYPE)



7.5 MODEL β8/8000*i* (FLANGE MOUNTING TYPE)

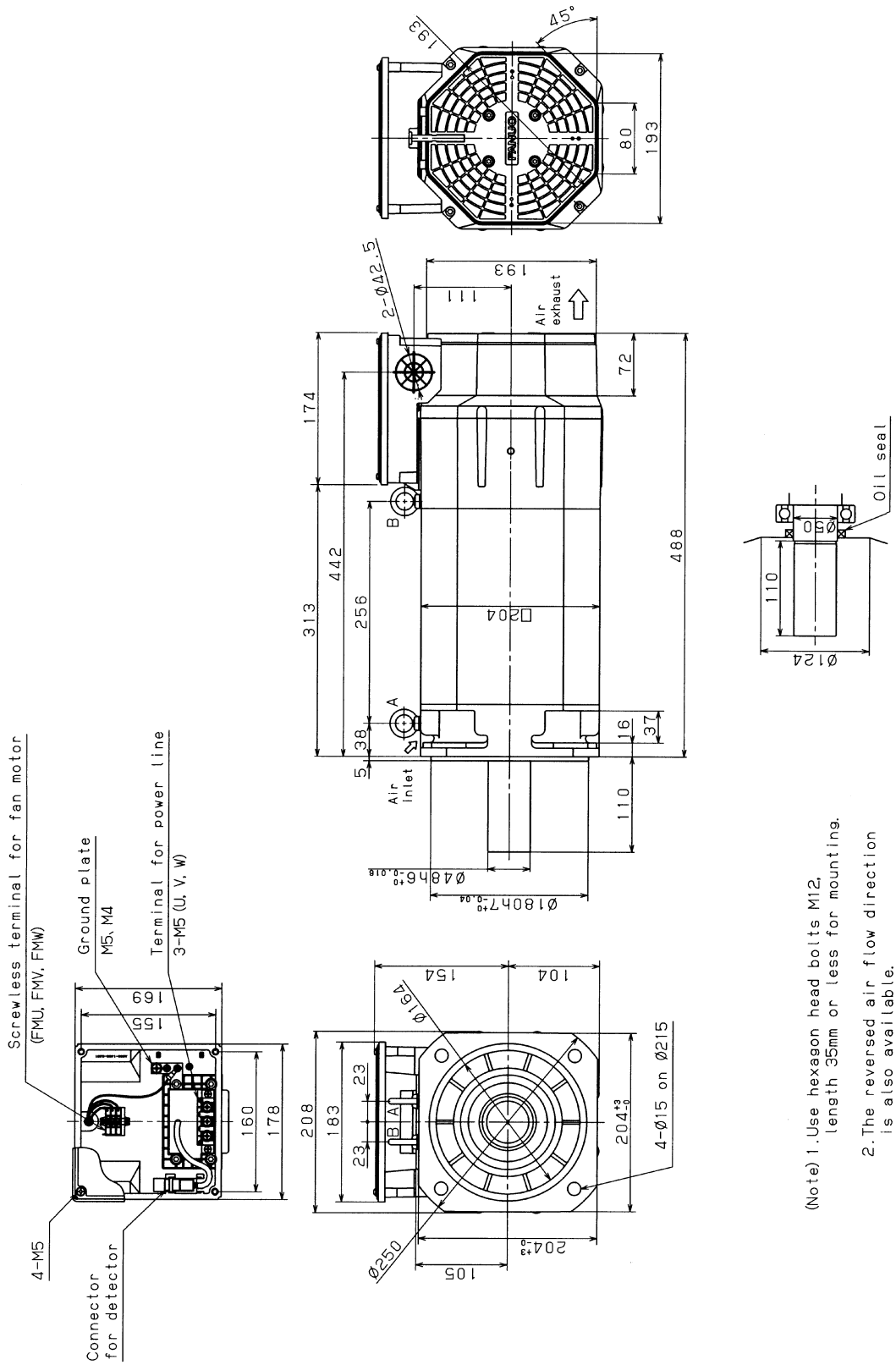


7.6 MODEL β8/8000*i* (FOOT MOUNTING TYPE)

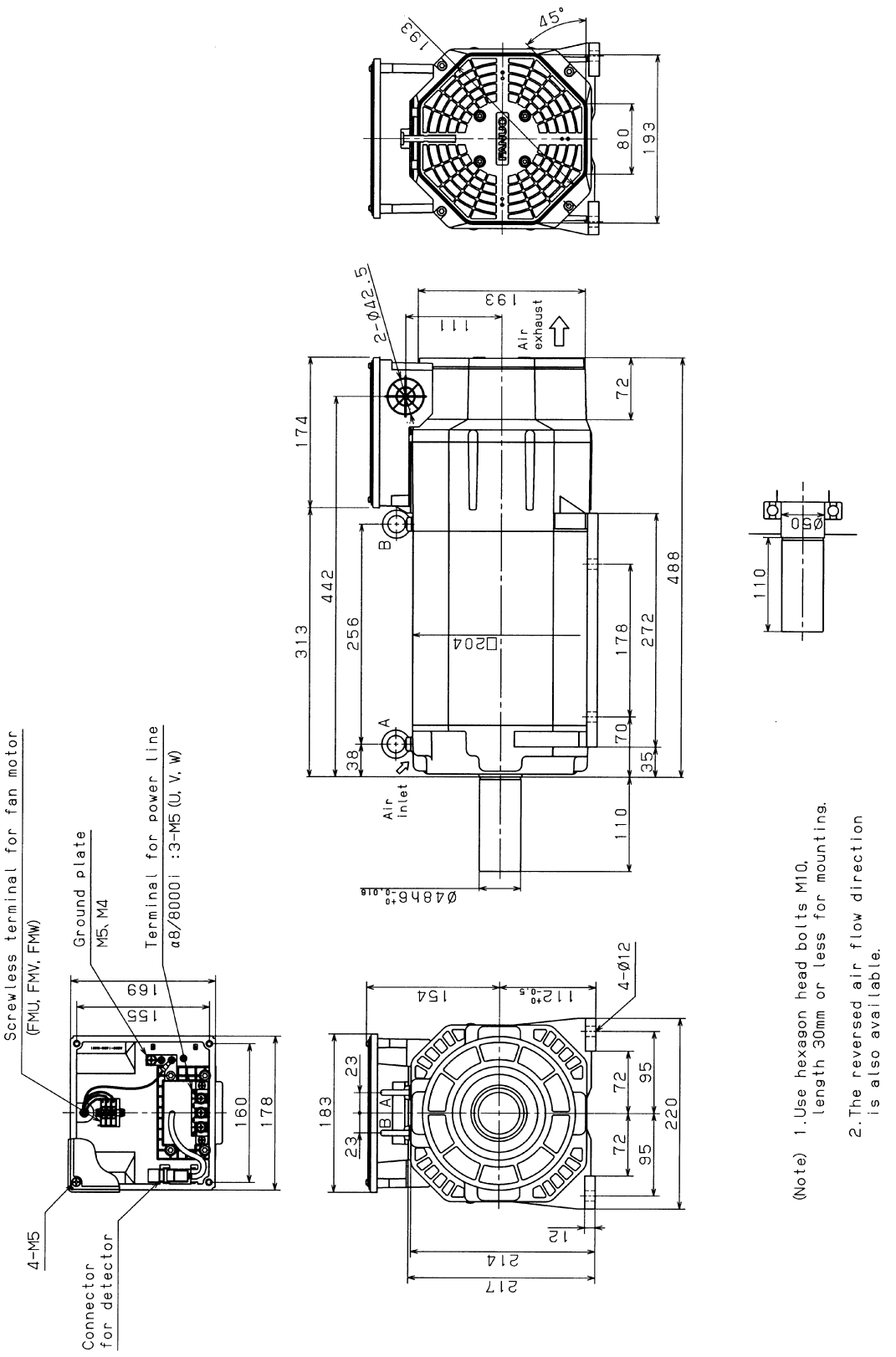


(Note) 1. Use hexagon head bolts M10, length 30mm or less for mounting.
2. The reversed air flow direction is also available.

7.7 MODEL β12/7000*i* (FLANGE MOUNTING TYPE)



7.8 MODEL β12/7000*i* (FOOT MOUNTING TYPE)



(Note) 1. Use hexagon head bolts M10, length 30mm or less for mounting.
2. The reversed air flow direction is also available.

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Revision Record

FANUC AC SPINDLE MOTOR βi series DESCRIPTIONS (B-65312EN)

Edition	Date	Contents	Edition	Date	Contents
01	May, 2003	———————————————			