RV®

MS JAB CM022

ISC ISO 14001 E055

JQA QUALITY SYSTEM ISO 9001 JQA-1190

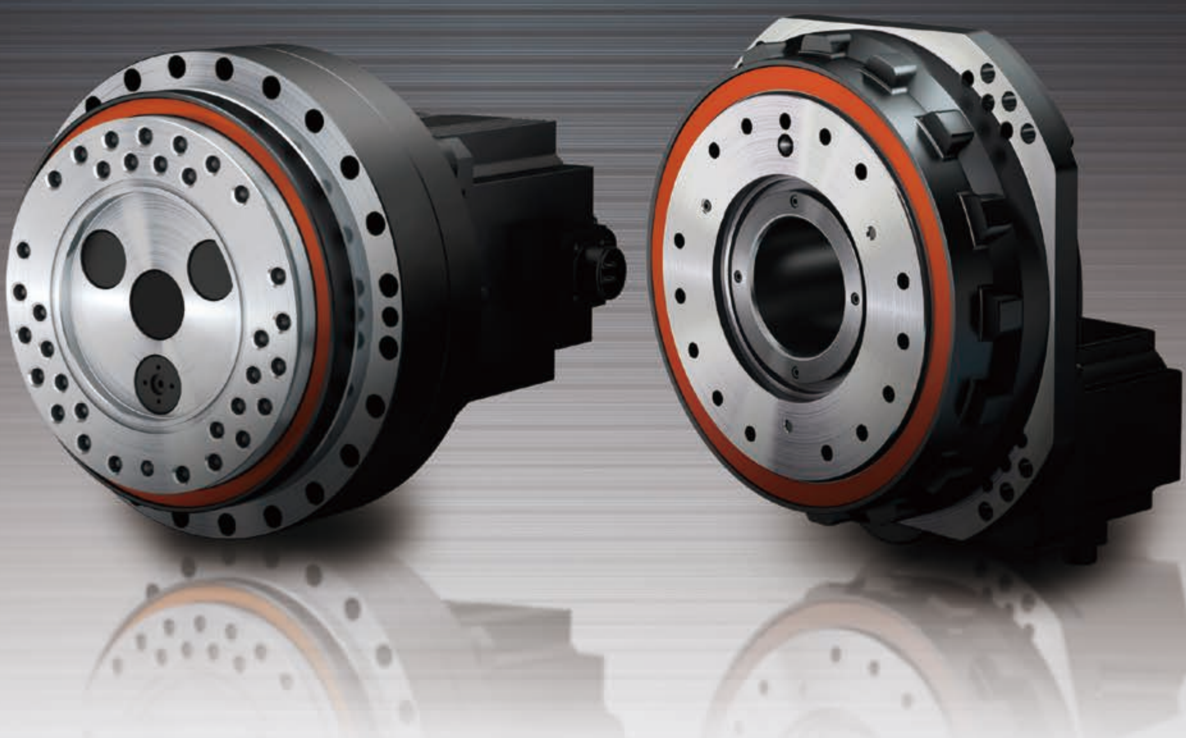
Precision Reduction Gear RV™

Compact Actuator

AF

AF Series

ALL in ONE

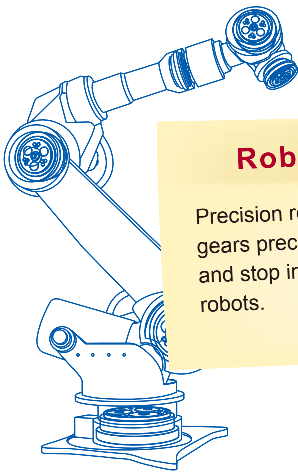


Nabtesco

Nabtesco's technologies supporting society

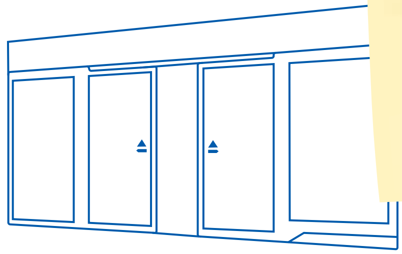
Contributing to society with our ‘Moving it. Stopping it.’ technologies

Nabtesco manufactures products which are used in everyday life. Our high-accuracy components are essential for moving objects; they may be rarely visible, but are the foundation of everyday objects that you see moving and wonder how. Nabtesco’s technologies are found throughout objects that move and stop people’s lives.



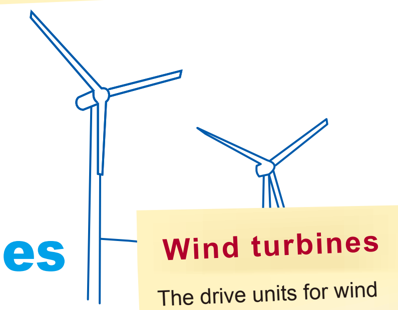
Robots

Precision reduction gears precisely move and stop industrial robots.



Doors

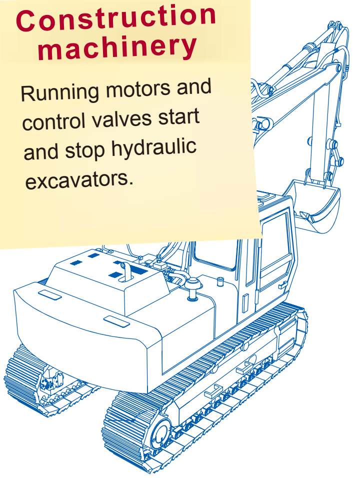
Nabtesco technology opens and closes automatic doors in buildings and platform doors at train stations.



Wind turbines

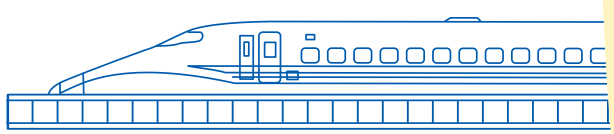
The drive units for wind turbine generators control the orientation of the wind turbine and the angle of the blades.

Nabtesco technologies are at work in many areas of our daily lives.



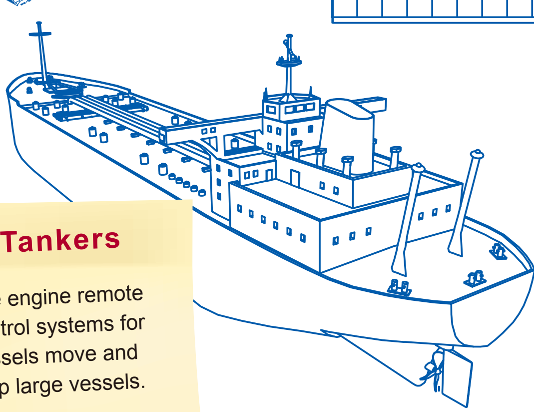
Construction machinery

Running motors and control valves start and stop hydraulic excavators.



Bullet trains

Brakes and doors ensure safety and comfort for the world-famous Shinkansen bullet trains.



Tankers

The engine remote control systems for vessels move and stop large vessels.

Airplanes

The flight control systems are crucial for the flight safety of aircraft.

CONTENTS

Who is Nabtesco?

The key words for Nabtesco are ‘motion control’. We use our strengths in the fields of component and systems technologies to develop highly creative products. Through the Nabtesco Group as a whole, we can also utilize our advantage of expertise to maximum effect in order to further enhance these strengths.
In the air, on land and at sea, we have a leading share in various fields of both international and domestic markets.
Nabtesco will continue to evolve by utilizing its strengths in many fields and by exploring the possibilities of the future.

April 2002 Initiation of hydraulic equipment business alliance
October 2003 Business merger

The business alliance between Teijin Seiki and NABCO on hydraulic equipment projects was the beginning of a mutual confirmation by the companies of the other’s product configuration, core technologies, corporate strategies and corporate culture. This led to a common recognition that a business merger would be an extremely effective means of increasing corporate value and achieving long-term development. Based on this mutual judgment, in 2003 an equity transfer was conducted to establish Nabtesco as a pure holding company, with both firms as wholly owned subsidiaries. After a year of preparation, both companies were absorbed and amalgamated by means of a short form merger, and Nabtesco was transitioned to an operating holding company.

Actuator for Factory Automation

Evolving into ALL in ONE

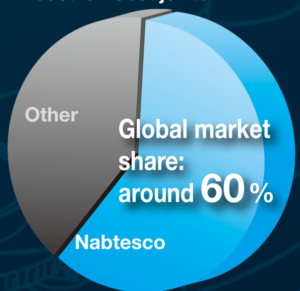
Do you want to automate –but don't have the time to spend selecting, designing and producing components? The AF series was created to provide a solution in such circumstances-to achieve automation as simple and quickly as possible. This has been achieved by integrating our precision reduction gear RV with servomotors from Panasonic Corporation into a simple, compact design. The resulting high quality unified drive section ensures safety, comfort, and a sense of security.

RV®: 60% of the global market share

RV precision gears utilize a planocentric deceleration mechanism for high-precision control. RV precision gears are compact and lightweight, and because RV precision gears include many simultaneously meshing surfaces, they feature high rigidity and strong resistance to overload. The design of the RV precision gear minimizes backlash, rotational vibration, and inertia; which leads to excellent acceleration performance, smooth movement, and high positioning accuracy. RV precision gears have a proven track record in many fields of automation, including: industrial robots, machine tools, assembly equipment, and transportation equipment.

- High rigidity and High impact resistance
- High output torque and High durability
- Low vibration
- Wide reduction ratio range
- Flat and Compact
- High precision positioning (precise rotation)

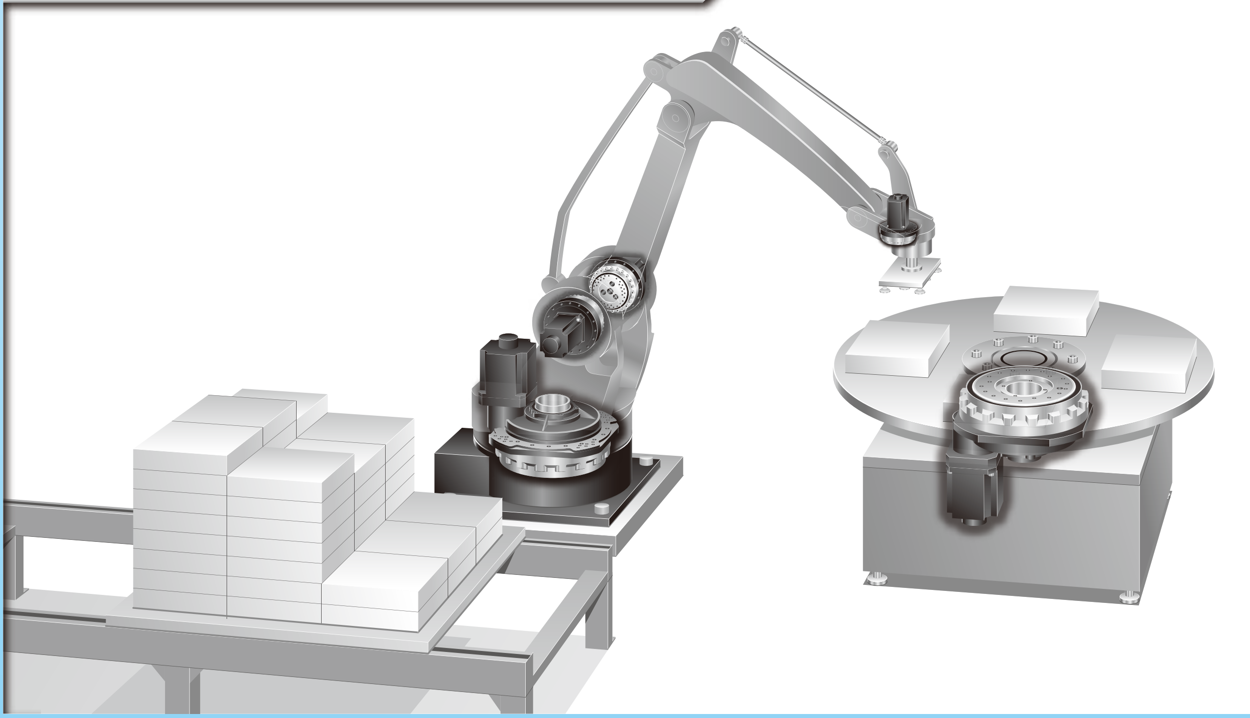
Precision gears for industrial robot joints



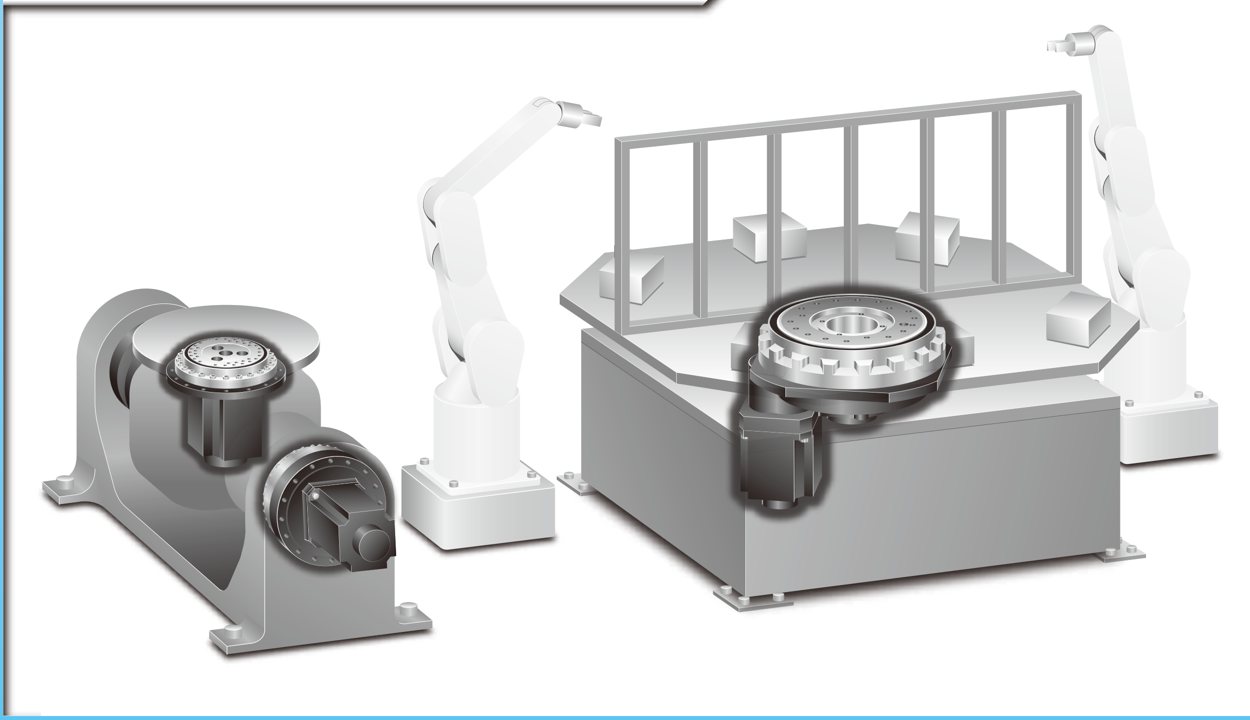
Main Applications

The following are example applications of automation using the AF series.
However, these precision gears can be incorporated
into a variety of other applications.

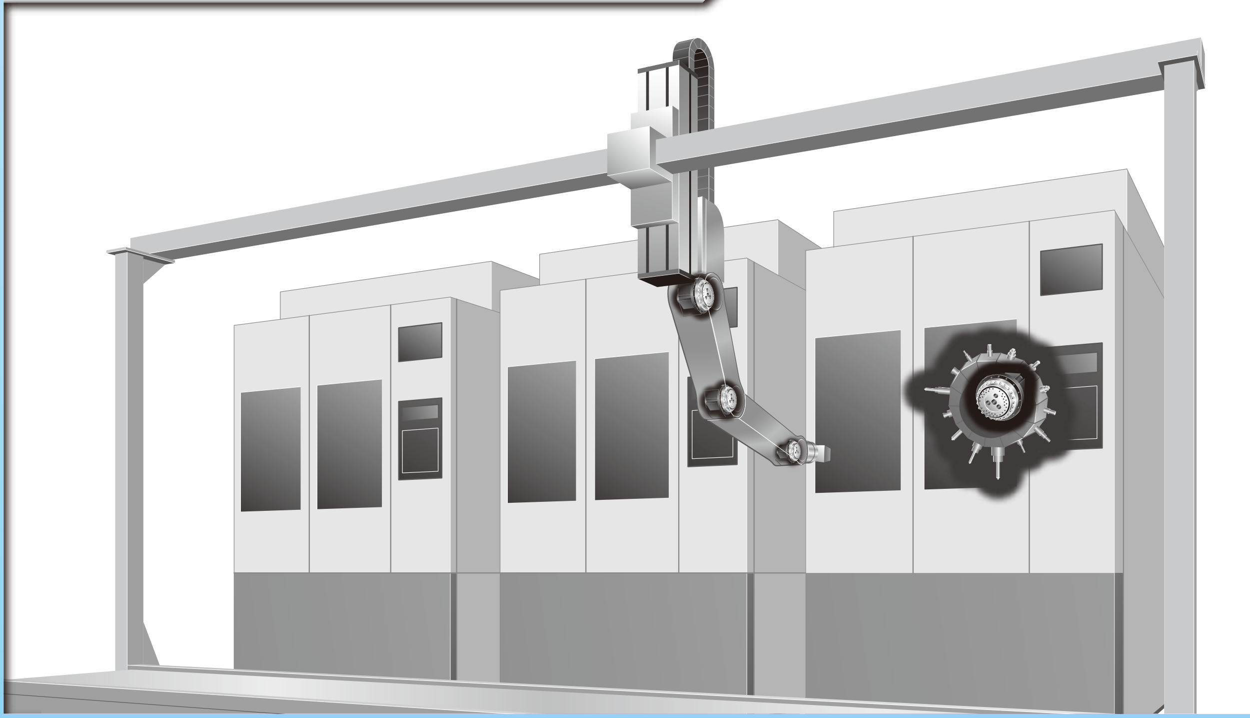
Palletizing robot and Index table



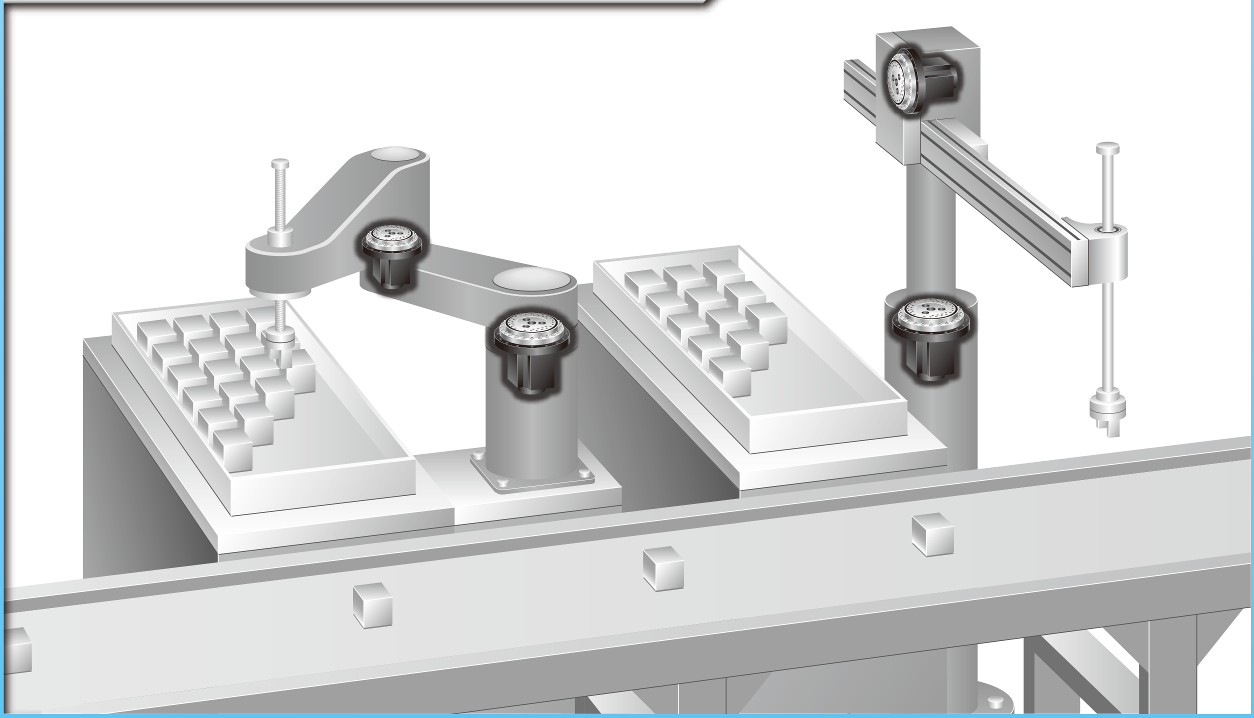
Various types of positioners



Gantry loader and ATC magazine



SCARA robot and Cylindrical coordinate robot

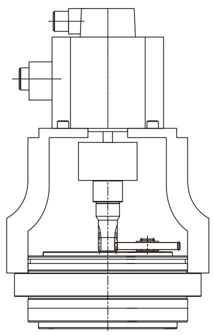


Benefits

The AF series can solve your problems.

Merit 1 Compact design

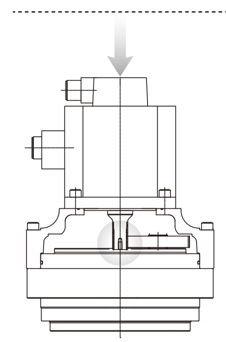
Before



The total length is extended due to the input gear and coupling.

With the AF series...

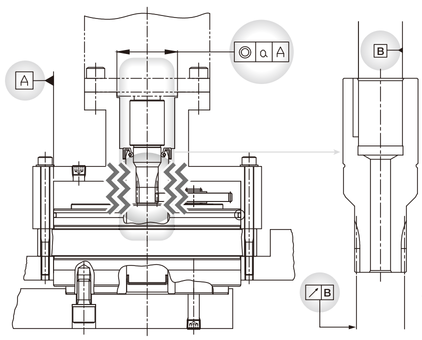
After



The machining of gears onto the motor shaft results in a very compact design;
up to 23% shorter than conventional models.

Merit 2 Greater reliability

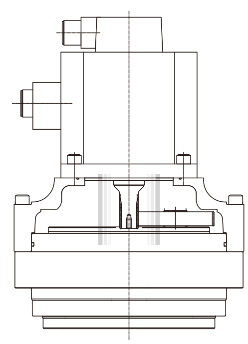
Before



Machining is very difficult, resulting in axial runout, poor concentricity accuracy, and producing abnormal noise.

With the AF series...

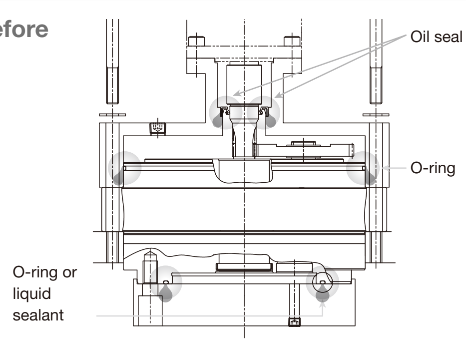
After



Shipped after machining and assembly,
no need to worry about abnormal noise.

Merit 3 Greater quality

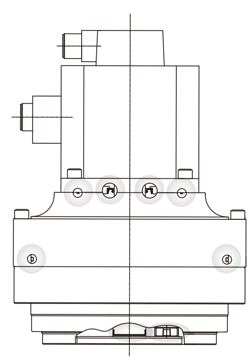
Before



Greaseing can be troublesome,
If seals are forgotten, grease can leak

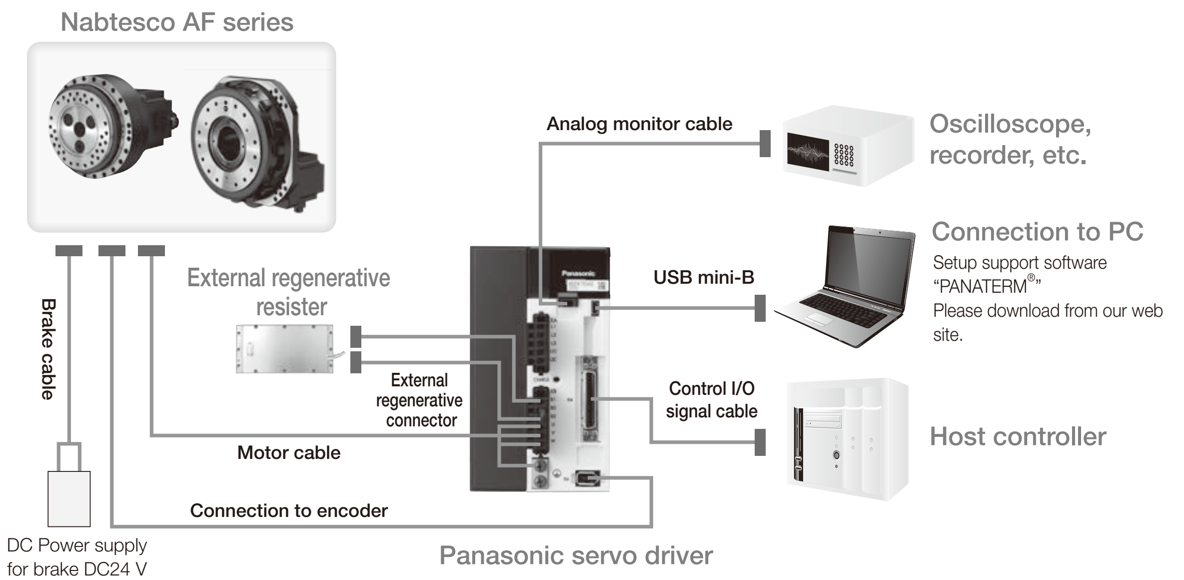
With the AF series...

After



Already contains grease;
no need to worry about leaking.

Overall Wiring

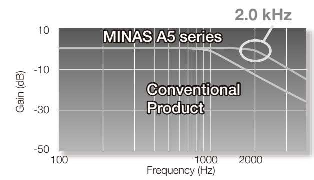


Features of Panasonic Servo Driver

Feature 1
Quick
High response

Achieves industory leading frequency response of 2.0 kHz

Operational speed is increased by the newly developed LSI and high response controls. With industry leading speed and positioning response, a highly advanced system can be created. The shorter response delay also leads to extremely low vibration.



Feature 2
Smart
Intelligent

High-performance real-time auto-gain tuning featuring simple setup

After installation and a few short operations, tuning will be completed automatically. When the response needs to be adjusted, simple tuning can be done by changing only one parameter value. Gain adjustment mode (in the setup support software) allows for optimal adjustment. The built-in auto vibration suppression function reduces the chance of equipment damage. Suitable modes are available for a variety of machines, such as vertical axis or high friction machines with belts. These modes make it possible to perform adjustments for optimization by simply selecting the mode and stiffness.

Equipped with auto-setting notch filters for greater convenience

Now there is no need to measure troublesome vibration frequencies. Our notch filters automatically detect vibration and provide simple auto-settings. These notch filters greatly reduce noise and vibration caused by equipment resonance and respond quickly to the A5 series during operation. The A5II, A5 series features an industry-largest total of four notch filters with setup frequencies of 50 Hz to 5,000 Hz. This approach enables depth adjustment within the frequency range (two of the filters share the auto set-up).

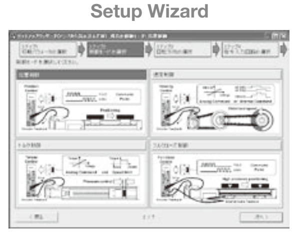
Feature 3
Easy
Easy

PANATERM set-up support software, with many included features

PANATERM assists users in setting parameters, monitoring control conditions, setup support, and analyzing mechanical operation data (when installed in a commercially available personal computer and connected to the MINAS A5 family through a USB interface).

- Localized in 4 languages
  Choose English, Japanese, Chinese, or Korean language display.

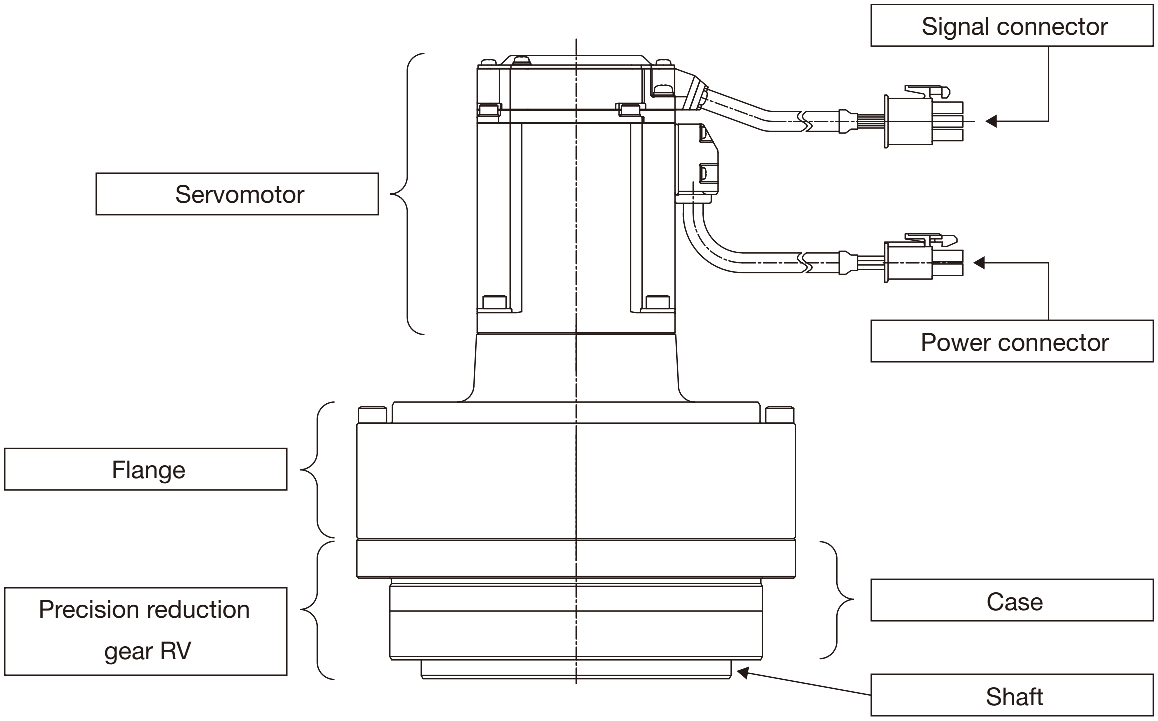
Setup Wizard



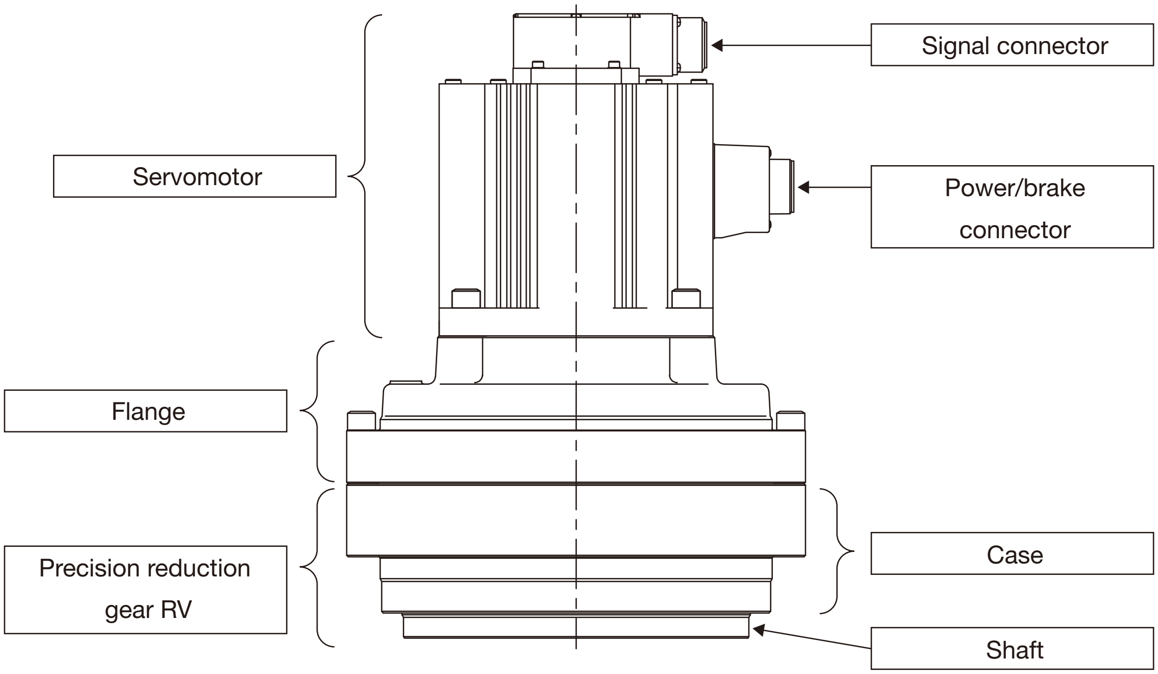
If anything is unclear or you need more detailed information, check the following URL.

Panasonic download site http://industrial.panasonic.com/ww/products/motors-compressors/motors-for-fa-and-industrial-application

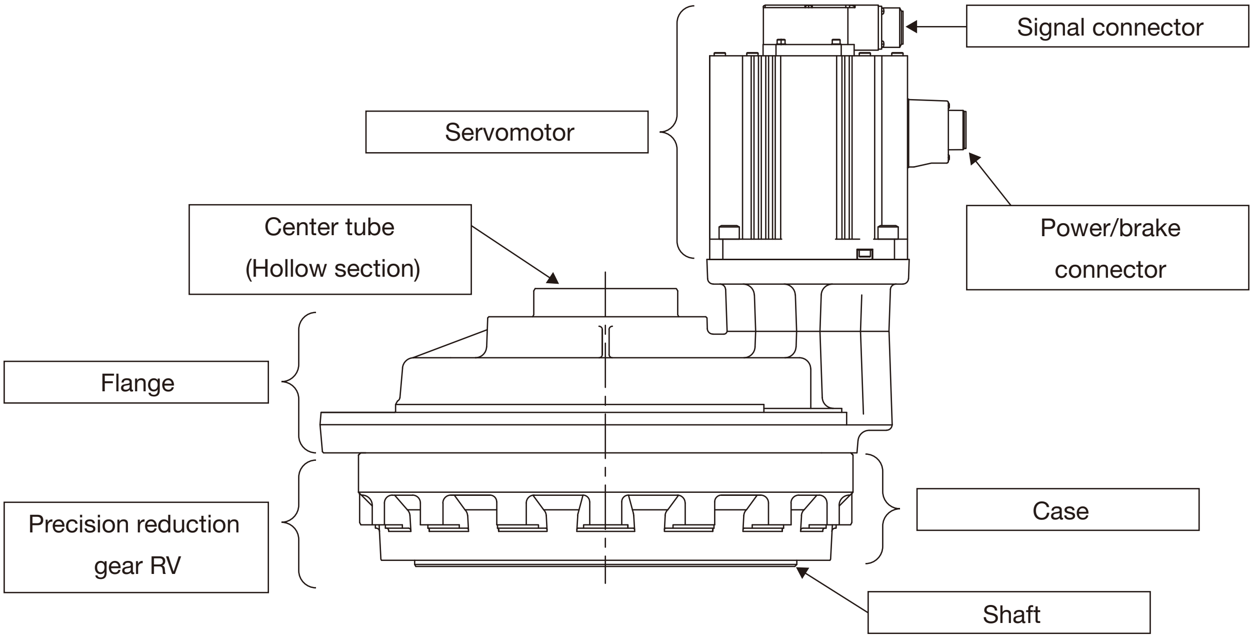
•Solid type (AF017N)



•Solid type (AF042N, AF125N, AF380N, AF500N)



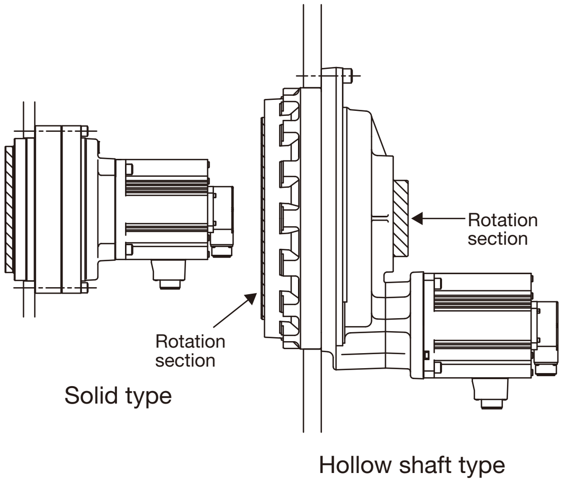
•Hollow shaft type (AF200C, AF320C)



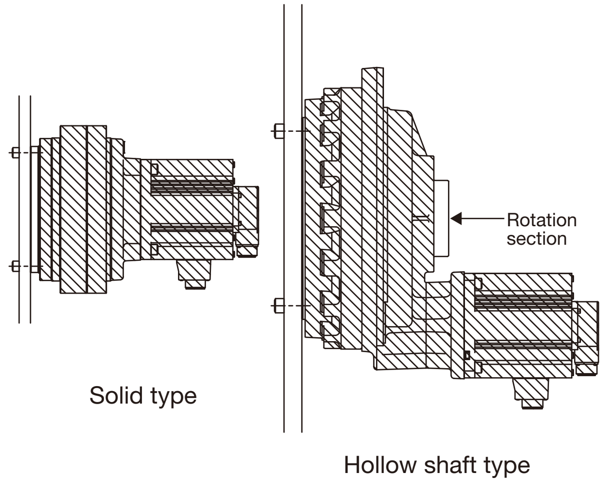
Rotation section selection

For this product, the fixed and rotation sections can be selected. Select appropriate fixed and rotation sections according to the requirements for the customer's device.

•Rotation section of case-fixed shaft rotation model



•Rotation section of shaft-fixed case rotation model



▨ : Rotation section

* Note) When using this product with case rotation, be careful about tangling of cables as the motor and cables connected to the motor also rotate.

Principle of speed reduction

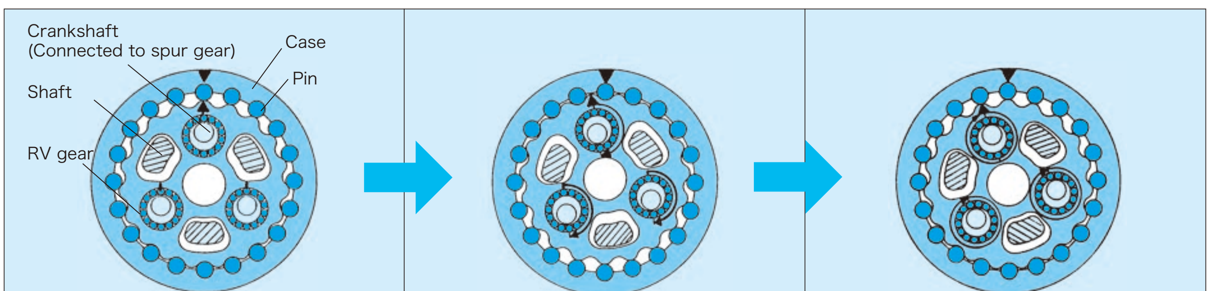
The RV is a 2-stage precision reduction gear.

1st stage … Spur gear reduction

- An input gear engages with and rotates spur gears that are coupled to crankshafts. Several overall gear ratios can be provided by selecting various first stage ratios.

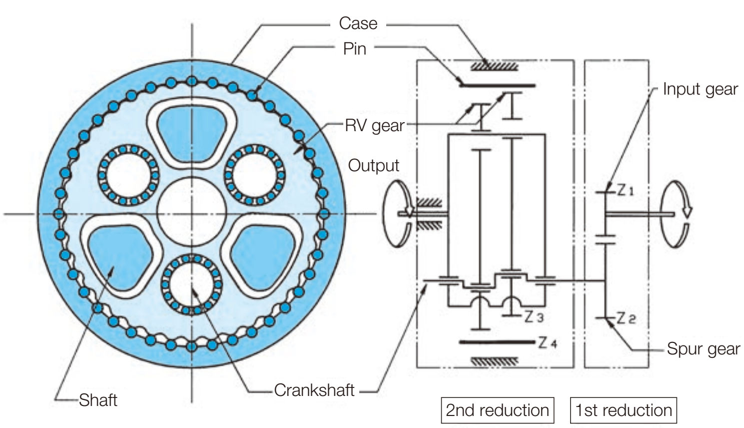
2nd stage … Epicyclic gear reduction

- Crankshafts driven by the spur gears cause an eccentric motion of two epicyclic gears called RV gears that are offset 180 degrees from one another to provide a balanced load.
- The eccentric motion of the RV gears causes engagement of the cycloidal shaped gear teeth with cylindrically shaped pins located around the inside edge of the case.
- In the course of one revolution of the crankshafts the teeth of the RV gear move the distance of one pin in the opposite direction of the rotating cranks. The motion of the RV gear is such that the teeth remain in close contact with the pins and multiple teeth share the load simultaneously.
- The output can be either the shaft or the case. If the case is fixed, the shaft is the output. If the shaft is fixed, the case is the output.

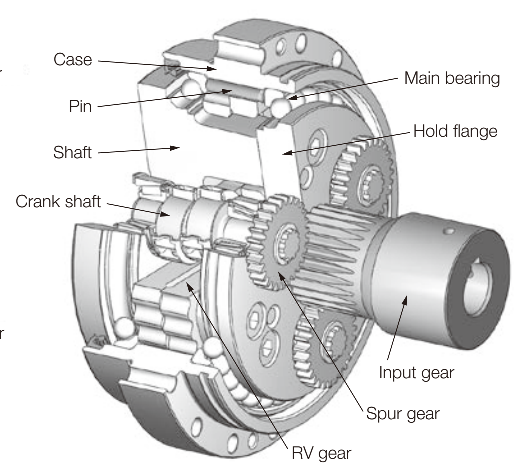


Crankshaft rotating angle: 0 degree — Rotating angle: 180 degrees — Rotating angle: 360 degrees

Mechanism block diagram



Structure



Speed Ratio

The speed ratio is calculated using the formula to the right.

$$R = 1 + \frac{Z2}{Z1} \cdot Z4$$

$$i = \frac{1}{R}$$

R : Speed ratio
Z1 : Number of teeth on input gear
Z2 : Number of teeth on spur gear
Z3 : Number of teeth on RV gear
Z4 : Number of pins
i : Reduction ratio

Product code

AF 042 N 093 – P1 0 – B A – S 0

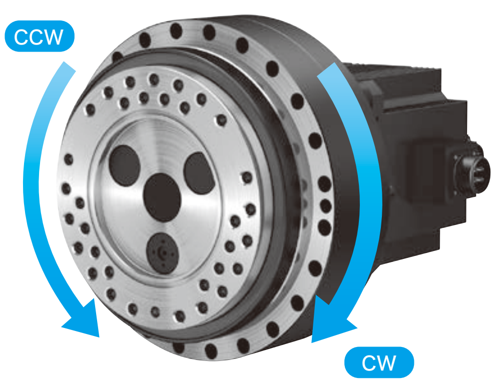
<table>
<tr><th>Series</th><th>Frame number</th><th>Shape</th><th>Ratio code</th><th>Fixing code</th><th>Motor type</th><th>Motor brake</th><th>Fixing code</th><th>Oil seal type</th><th>Option code</th></tr>
<tr><td rowspan="7">AF</td><td>017</td><td rowspan="5">N:
Solid type</td><td>081</td><td>P0</td><td>1:
A6 series</td><td>0: Without motor brake</td><td>B</td><td rowspan="5">S:
Single oil seal
Single oil seal is standard.</td><td rowspan="7">0: Standard component
Indicates the option code. Currently, only the code for standard components is available.</td></tr>
<tr><td>042</td><td>093</td><td>P1</td><td rowspan="6">0:
A5 series</td><td rowspan="6">B:
With motor brake</td><td rowspan="6">A</td></tr>
<tr><td>125</td><td>102</td><td>P2</td></tr>
<tr><td>380</td><td>217</td><td>P3</td></tr>
<tr><td>500</td><td>252</td><td>P3</td></tr>
<tr><td>200</td><td rowspan="2">C:
Hollow shaft type</td><td>155</td><td>P2</td><td rowspan="2">D:
Double oil seal
Double oil seal is standard.</td></tr>
<tr><td>320</td><td>157</td><td>P5</td></tr>
</table>

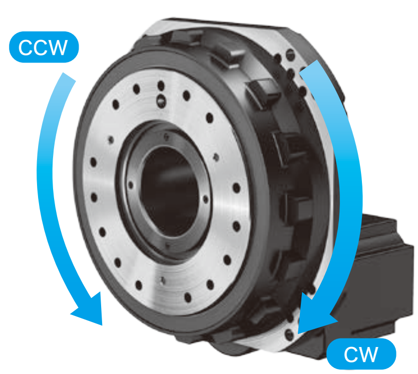
Rotation direction

The relationship between the motor rotation direction and output stage rotation direction is shown below. As the motor rotation direction and output stage rotation direction may be reversed, check the following table.

<table>
<tr><th colspan="2" rowspan="2"></th><th colspan="2">Motor rotation direction</th></tr>
<tr><th>CW</th><th>CCW</th></tr>
<tr><td rowspan="2">Shaft rotation direction when the case is fixed</td><td>Solid type</td><td>CW</td><td>CCW</td></tr>
<tr><td>Hollow shaft type</td><td>CCW</td><td>CW</td></tr>
<tr><td rowspan="2">Case rotation direction when the shaft is fixed</td><td>Solid type</td><td>CCW</td><td>CW</td></tr>
<tr><td>Hollow shaft type</td><td>CW</td><td>CCW</td></tr>
</table>

The information in the table above indicates the rotation direction viewed from the output stage side.





Note: CW indicates clockwise and CCW indicates counterclockwise when viewed from the output side.

International standards

This product complies with UL, cUL and European safety standards.

Rating table

Lineup			Solid type					Hollow shaft type	
	Item	Unit	AF017N	AF042N	AF125N	AF380N	AF500N	AF200C	AF320C
Actuator	Rated torque[1]	Nm	82	355	1,169	3,329	3,856	1784	3002
Actuator	Momentary maximum torque[2]	Nm	289	1,029	3,062	9,310	11,567	4900	7840
Actuator	Brake holding torque (Min.)[7]	Nm	-	456	2,503	5,338	6,182	2527	3847
Actuator	Rated output speed[1]	min^{-1}	37.0	21.5	19.6	9.2	7.9	12.8	12.7
Actuator	Momentary maximum output speed	min^{-1}	80.2	32.3	29.4	13.8	11.9	19.2	19.1
Actuator	Single-direction repeatability (Max.)	arc.sec.	70	60	50	50	50	50	50
Actuator	Allowable load inertia moment	kgm^2	11	51	372	2,036	2,732	345	1,314
Actuator	Allowable moment[8]	Nm	784	1,660	3,430	7,050	11,000	8,820	20,580
Actuator	Momentary maximum allowable moment	Nm	1,568	3,320	6,860	14,100	22,000	17,640	39,200
Actuator	Allowable radial load[9]	N	6,975	12,662	19,804	28,325	40,486	31,455	57,087
Actuator	Mass	kg	9	17	40	77	93	100	163
Actuator	Speed ratio		81	93	102.18 (1737/17)	217.86 (1525/7)	252.33 (757/3)	155.96	157
Actuator	Backlash	arc.min.	≤ 1	≤ 1	≤ 1	≤ 1	≤ 1	≤ 1	≤ 1
Actuator	Lost motion	arc.min.	≤ 1	≤ 1	≤ 1	≤ 1	≤ 1	≤ 1	≤ 1
Actuator / Motor[4]	Manufacturer		Panasonic Corporation						
Actuator / Motor[4]	Series		A6	A5	A5	A5	A5	A5	A5
Actuator / Motor[4]	Representative model		MHMF042L2	MDME102SC	MHME302SC	MDME402SC	MDME402SC	MDME302SC	MDME502SC
Actuator / Motor[4]	Rated capacity	kW	0.4	1.0	3.0	4.0	4.0	3.0	5.0
Actuator / Motor[4]	Rated current	Arms	2.1	5.7	16.0	21.0	21.0	17.4	25.9
Actuator / Motor[4]	Momentary maximum current	A (0-p)	10	24	68	89	89	74	110
Actuator / Motor[4]	Brake excitation voltage	V	-	DC 24 V ±2.4					
Actuator / Motor[4]	Brake excitation current	A	-	0.59	1.3	1.3	1.3	0.9	1.3
Actuator / Motor[4]	Brake suction time (Max.)	msec	-	80	80	80	80	110	80
Actuator / Motor[4]	Brake release time (Max.)[6]	msec	-	70	25	25	25	50	25
Actuator / Motor[4]	Brake application		-	Hold					
Actuator / Motor[4]	Position detector		Note: 10.	Single rotation: 17-bit absolute, Multi-rotation: 16-bit (battery backup)					
Compatible servo amplifier[5]	Manufacturer		Panasonic Corporation						
Compatible servo amplifier[5]	A5 Ⅱ analog/pulse		-	MDDKT3530***	MFDKTA390***	MFDKTB3A2***	MFDKTB3A2***	MFDKTA390***	MFDKTB3A2***
Compatible servo amplifier[5]	A5 Ⅱ N RTEX network		-	MDDHT3530ND1	MFDHTA390ND1	MFDHTB3A2ND1	MFDHTB3A2ND1	MFDHTA390ND1	MFDHTB3A2ND1
Compatible servo amplifier[5]	A5A RS485 AE link network		-	MDDHT3530A**	MFDHTA390A**	MFDHTB3A2A**	MFDHTB3A2A**	MFDHTA390A**	MFDHTB3A2A**
Compatible servo amplifier[5]	A5B EtherCAT network		-	MDDHT3530BD1	MFDHTA390BD1	MFDHTB3A2BD1	MFDHTB3A2BD1	MFDHTA390BD1	MFDHTB3A2BD1
Compatible servo amplifier[5]	A6 analog/pulse		MBDLN25S****	-	-	-	-	-	-
Compatible servo amplifier[5]	Power voltage		AC 200 to 230 V +10%, -15% 50/60Hz						
Compatible servo amplifier[5]	Motor torque limit[3]	%	350	289	261	279	300	274	261

Note:
1. The torque is calculated with consideration of the reduction speed ratio and reduction gear efficiency from the rated motor torque and rated rotation speed. This product is also designed under the assumption that it is used for positioning. Contact us when using this product for continuous operation or frequent positioning.

2, 3. Set the torque limit of the servo amplifier so that the torques does not exceed the momentary maximum torque of the compact actuator.

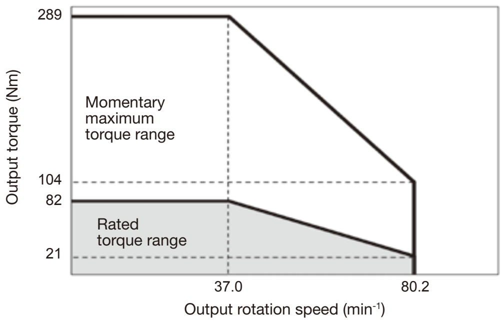
4, 5. For details on the servomotor and servo amplifier, see the operation manual issued by Panasonic Corporation.

6. The release time shows a value for a DC brake when a surge absorber is used. For details on the surge absorber, see the product catalog issued by Panasonic Corporation.
7. The torque is calculated with consideration of the reduction speed ratio and reduction gear efficiency from the motor brake holding torque.
8. The allowable moment will differ depending on the thrust load. Check the allowable moment diagram (page 14).
9. When the radial load is applied within dimension b on page 32, use the actuator within the allowable radial load.
10. Single rotation: 23-bit absolute, Multi-rotation: 16-bit (battery backup)

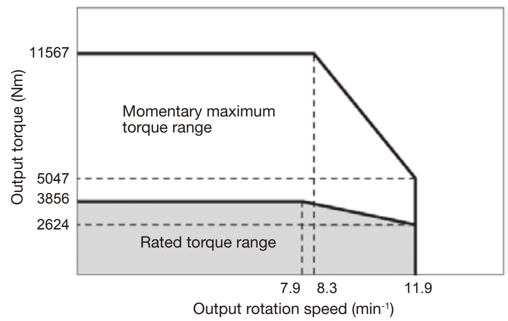
Torque range

The momentary maximum torque range and rated torque range of this product are indicated below.

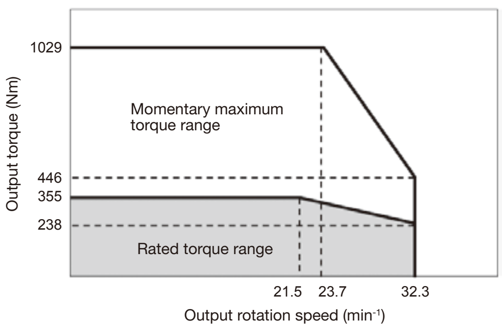
AF017N



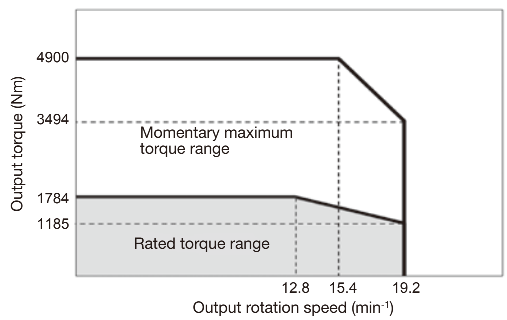
AF500N



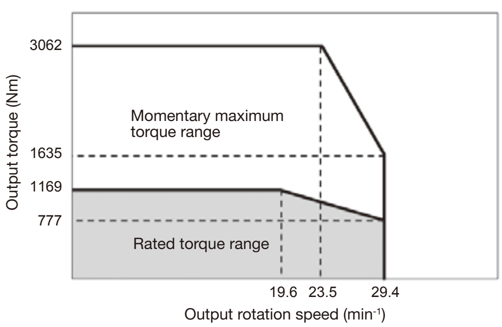
AF042N



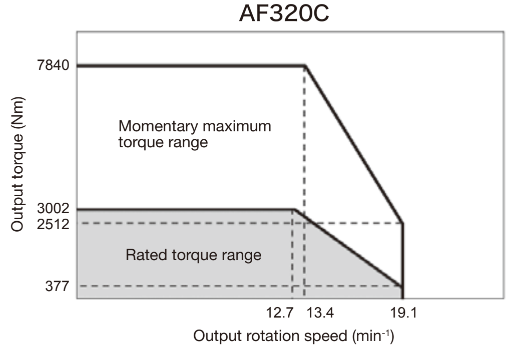
AF200C



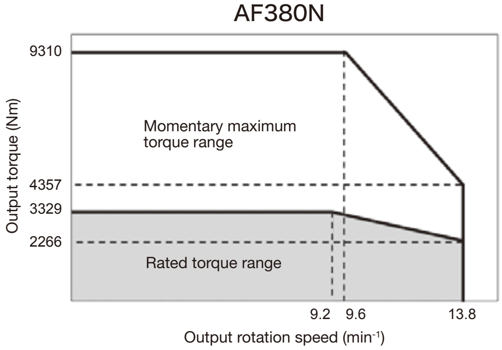
AF125N



AF320C



AF380N



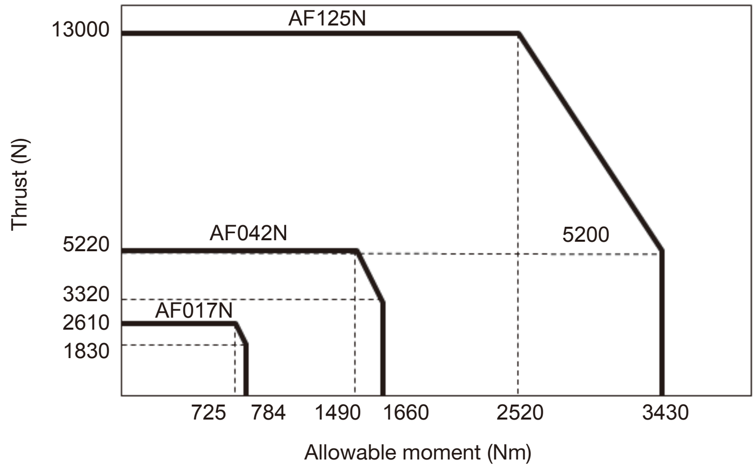
Important

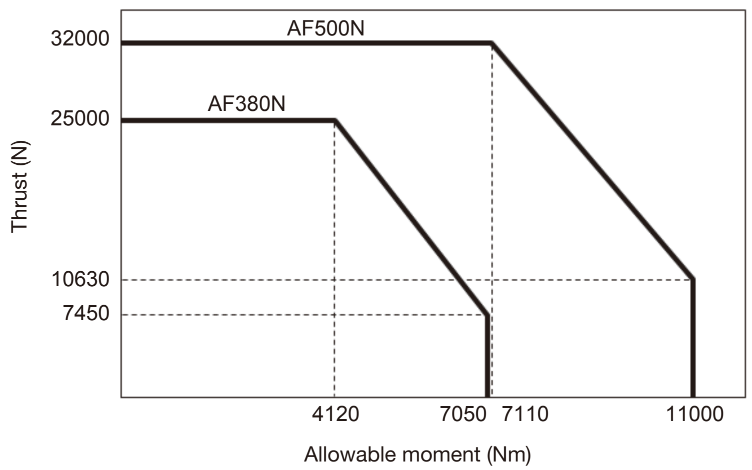
The momentary maximum torque range and rated torque range of this product are shown using values calculated with consideration of the momentary maximum torque range of the motor, rated torque range, reduction speed ratio, reduction gear efficiency, etc.

Allowable moment diagram

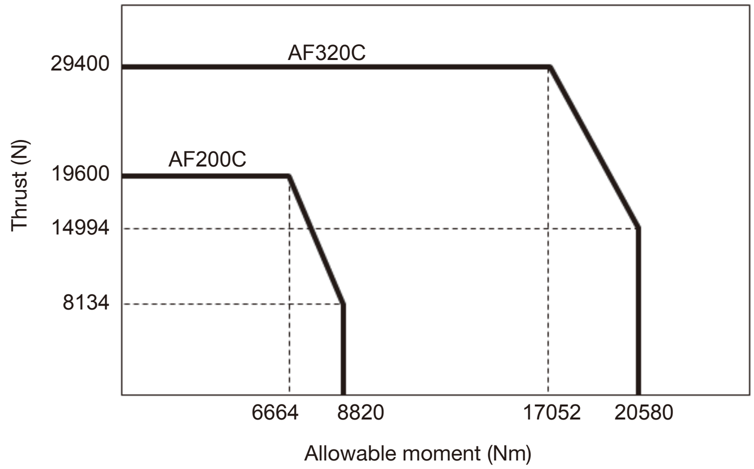
The allowable moment diagram of this product is shown below.

Allowable moment diagram for solid type

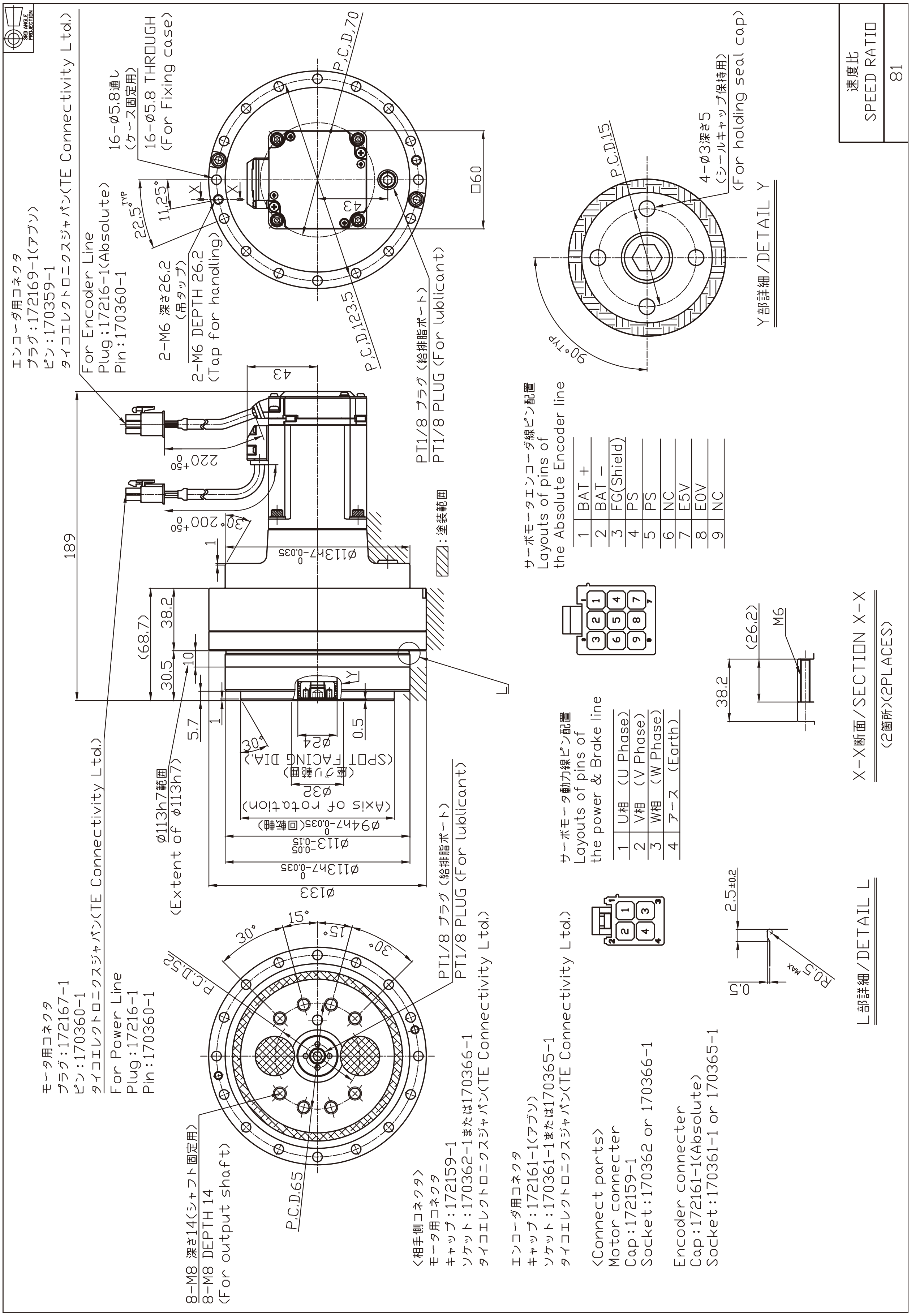




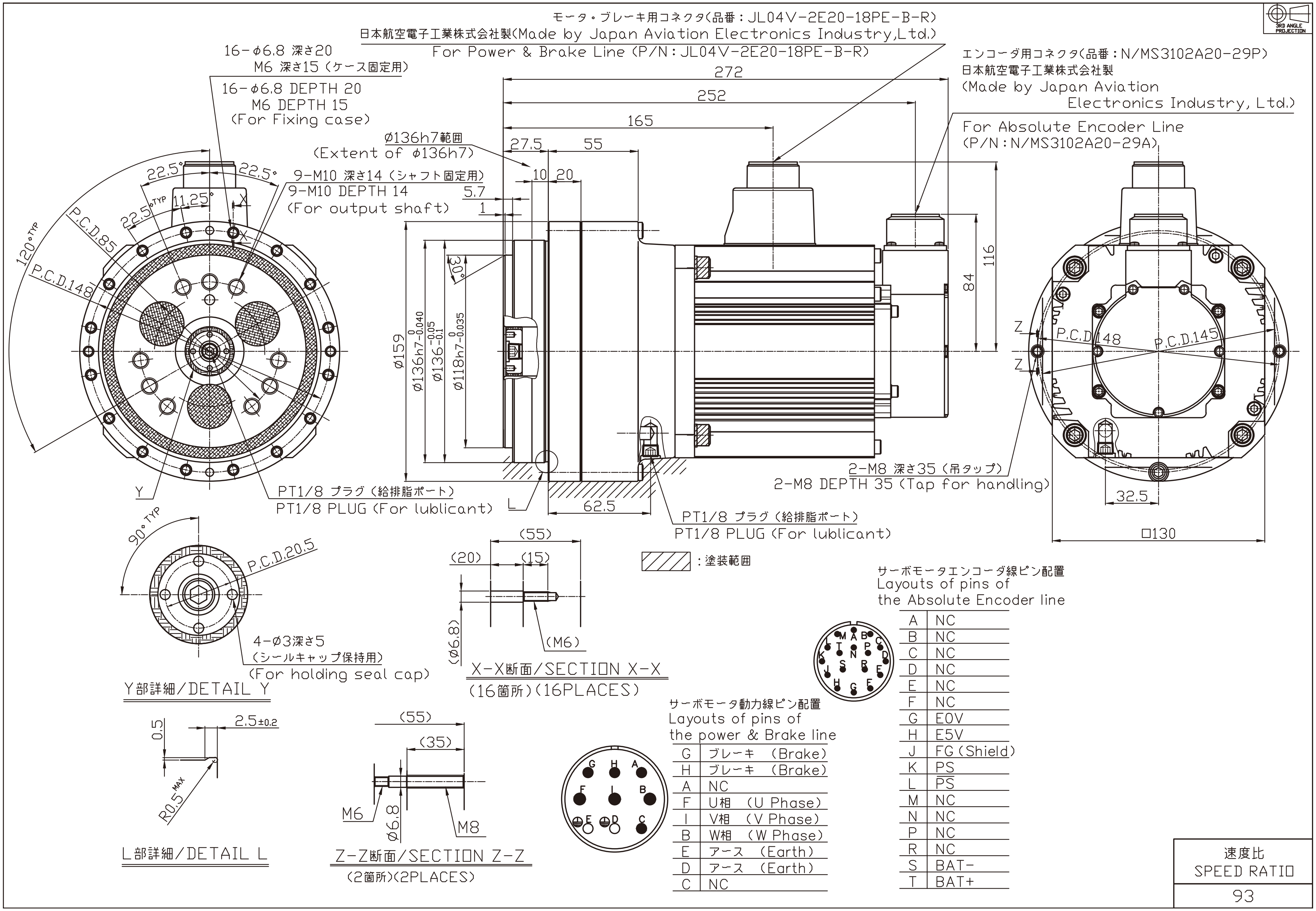
Allowable moment diagram for hollow shaft type



Model code : AF017N081-P01-0B-XX



Model code : AF042N093-P10-BA-XX



サーボモータ動力線ピン配置
Layouts of pins of
the power & Brake line

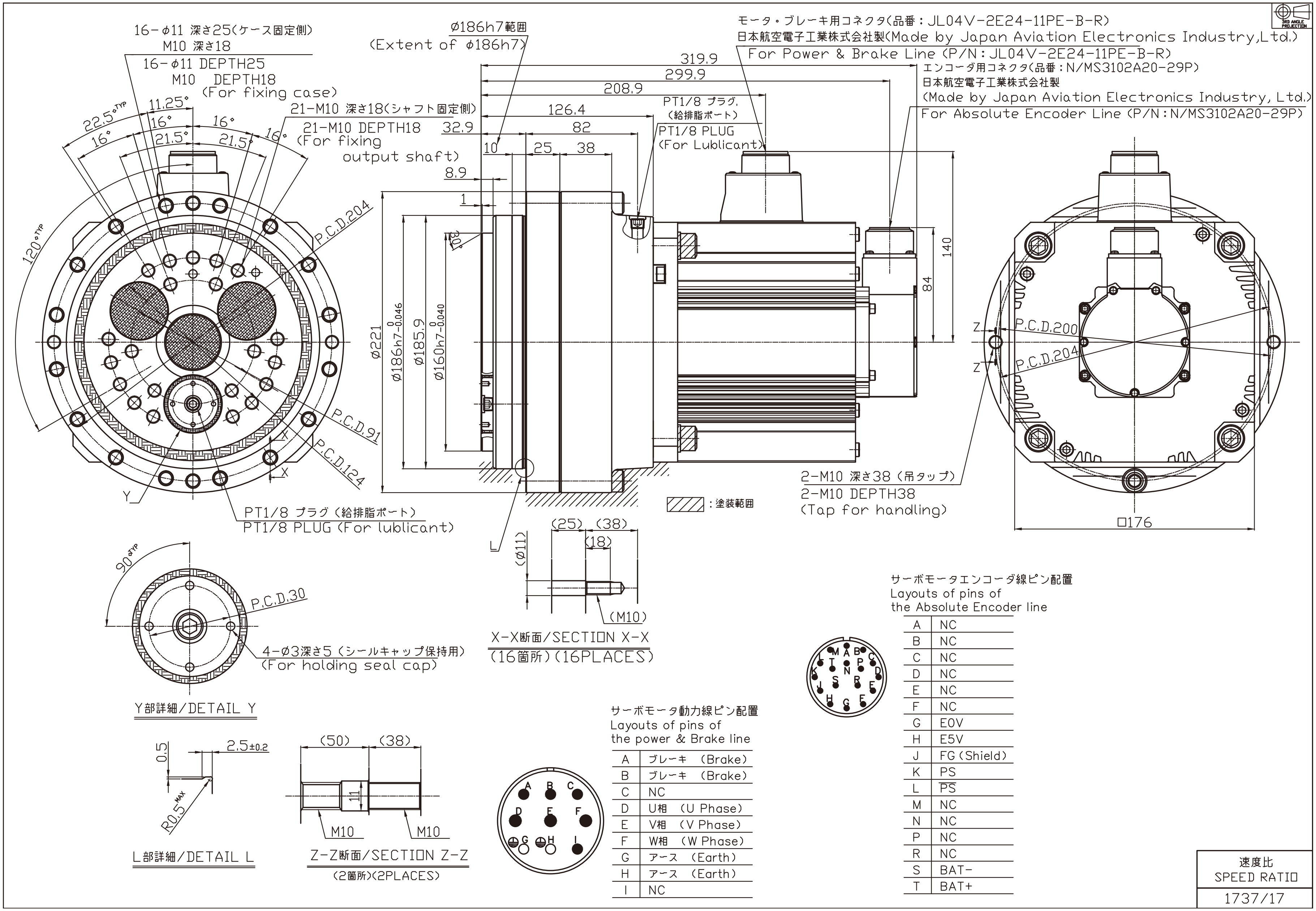
G	ブレーキ (Brake)
H	ブレーキ (Brake)
A	NC
F	U相 (U Phase)
I	V相 (V Phase)
B	W相 (W Phase)
E	アース (Earth)
D	アース (Earth)
C	NC

サーボモータエンコーダ線ピン配置
Layouts of pins of
the Absolute Encoder line

A	NC
B	NC
C	NC
D	NC
E	NC
F	NC
G	E0V
H	E5V
J	FG (Shield)
K	PS
L	PS
M	NC
N	NC
P	NC
R	NC
S	BAT-
T	BAT+

速度比 SPEED RATIO
93

Model code : AF125N102-P20-BA-XX



サーボモータ動力線ピン配置
Layouts of pins of
the power & Brake line

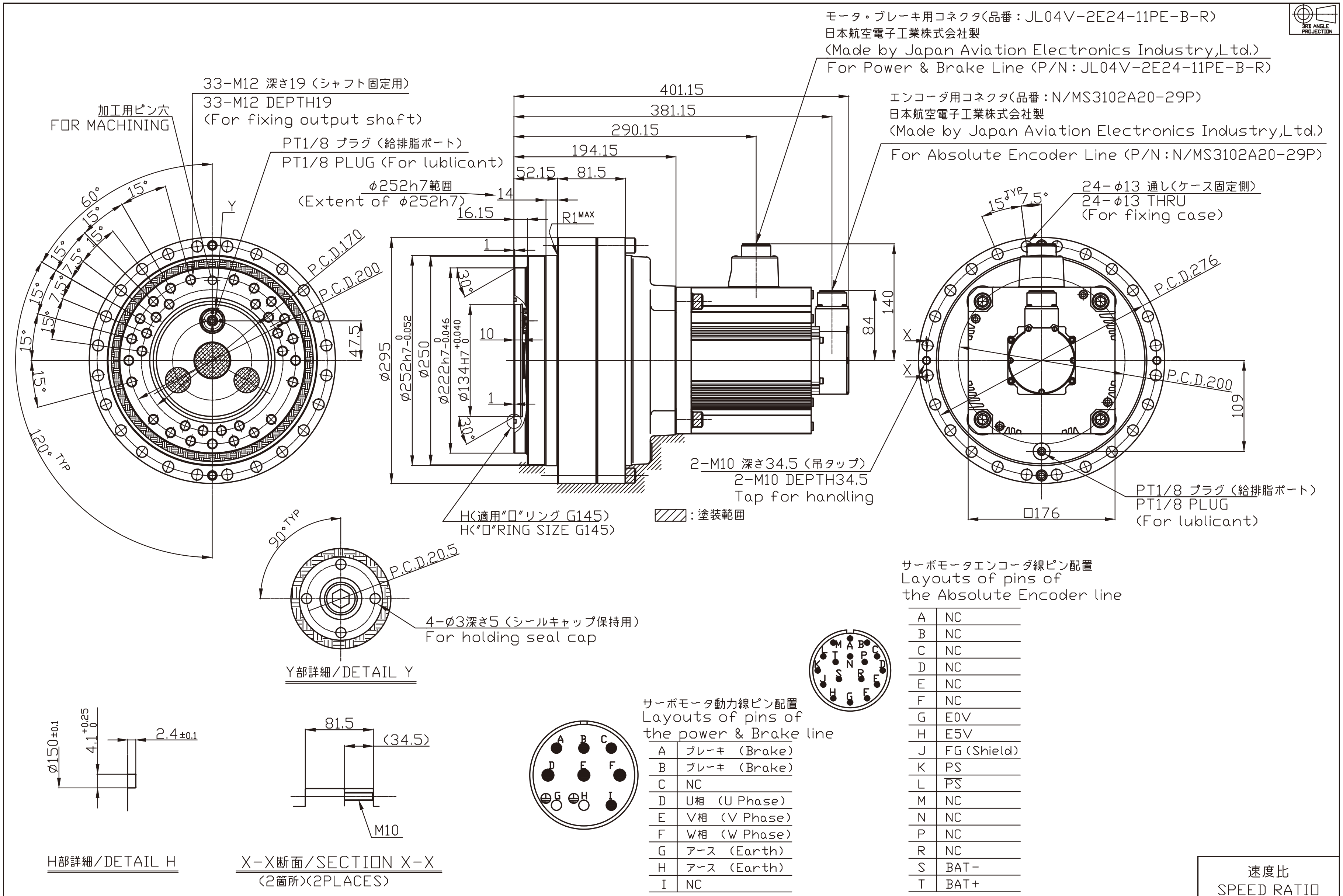
A	ブレーキ (Brake)
B	ブレーキ (Brake)
C	NC
D	U相 (U Phase)
E	V相 (V Phase)
F	W相 (W Phase)
G	アース (Earth)
H	アース (Earth)
I	NC

サーボモータエンコーダ線ピン配置
Layouts of pins of
the Absolute Encoder line

A	NC
B	NC
C	NC
D	NC
E	NC
F	NC
G	E0V
H	E5V
J	FG (Shield)
K	PS
L	PS
M	NC
N	NC
P	NC
R	NC
S	BAT−
T	BAT+

速度比 SPEED RATIO
1737/17

Model code : AF380N217-P30-BA-XX



サーボモータ動力線ピン配置
Layouts of pins of
the power & Brake line

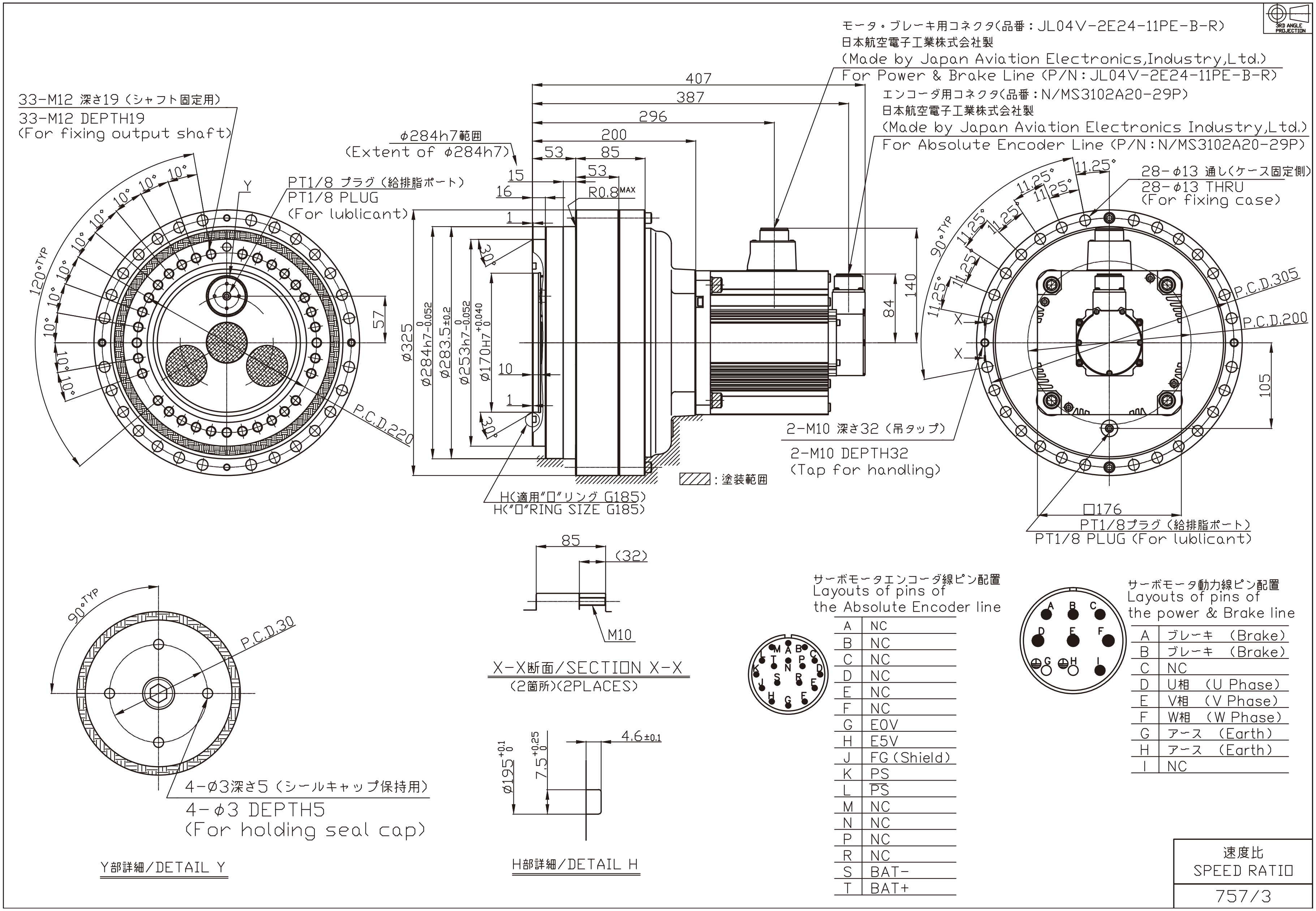
A	ブレーキ (Brake)
B	ブレーキ (Brake)
C	NC
D	U相 (U Phase)
E	V相 (V Phase)
F	W相 (W Phase)
G	アース (Earth)
H	アース (Earth)
I	NC

サーボモータエンコーダ線ピン配置
Layouts of pins of
the Absolute Encoder line

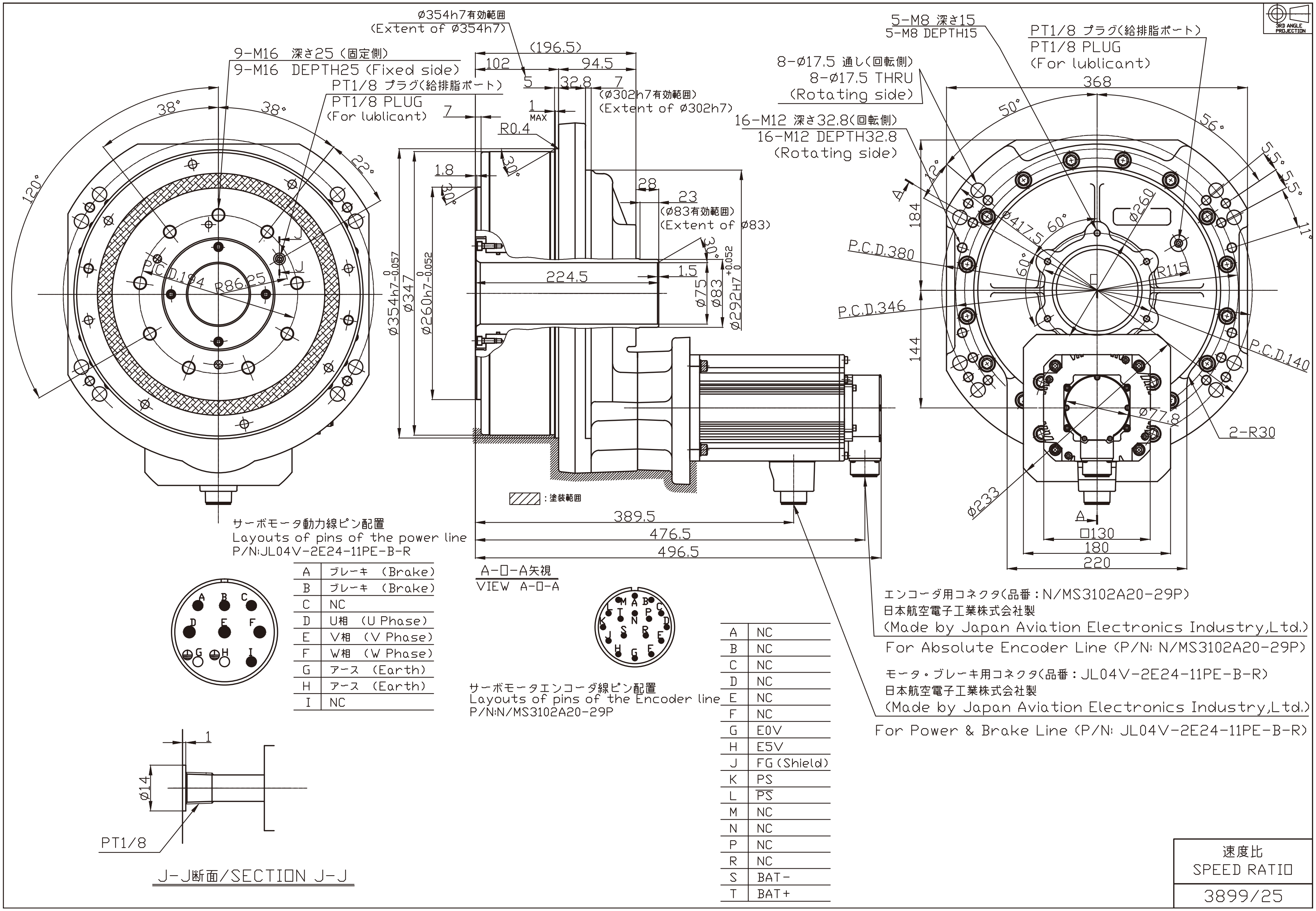
A	NC
B	NC
C	NC
D	NC
E	NC
F	NC
G	E0V
H	E5V
J	FG (Shield)
K	PS
L	PS
M	NC
N	NC
P	NC
R	NC
S	BAT-
T	BAT+

速度比 SPEED RATIO
1525/7

Model code : AF500N252-P30-BA-XX



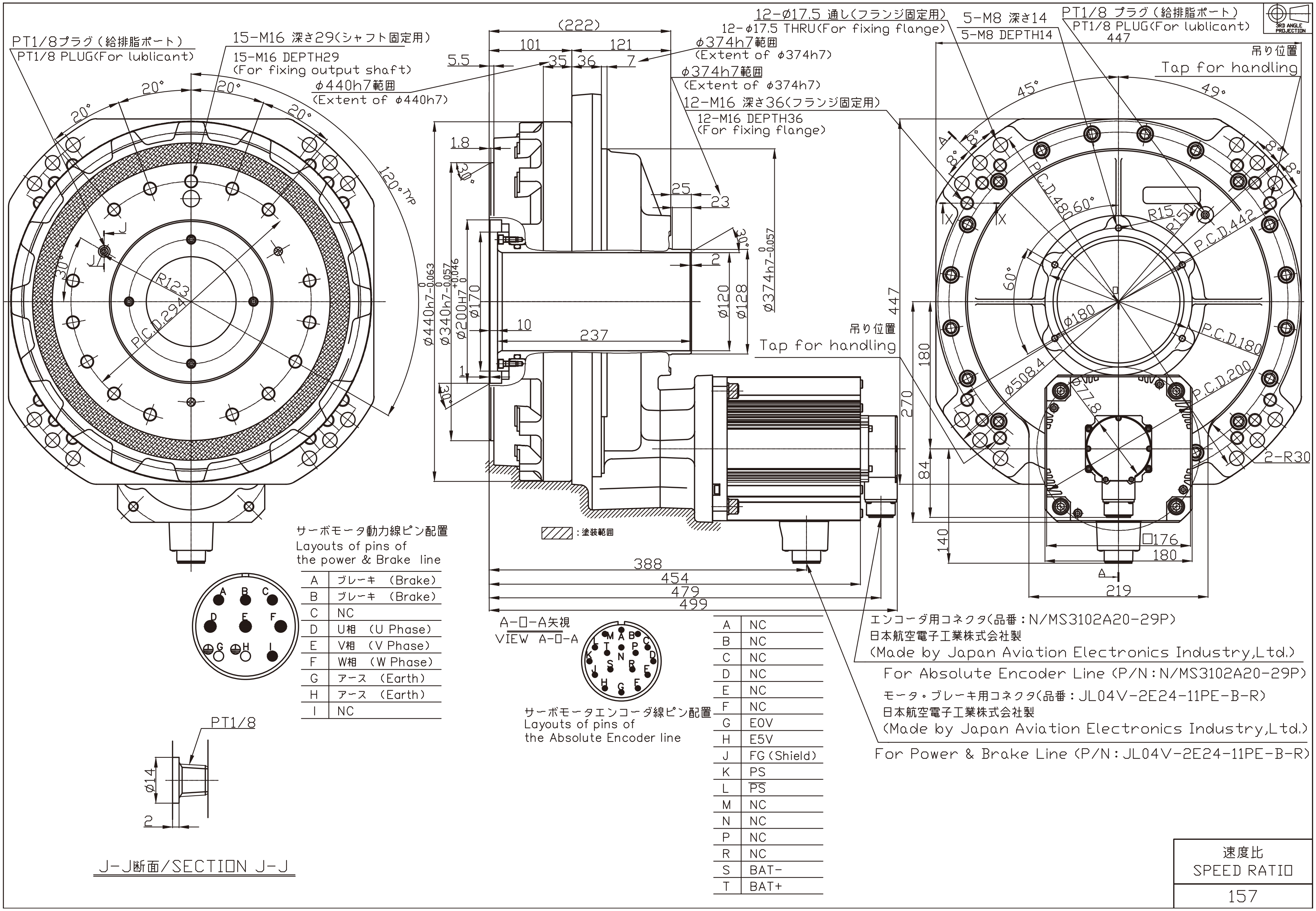
Model code : AF200C155-P20-BA-XX



A	ブレーキ (Brake)
B	ブレーキ (Brake)
C	NC
D	U相 (U Phase)
E	V相 (V Phase)
F	W相 (W Phase)
G	アース (Earth)
H	アース (Earth)
I	NC

A	NC
B	NC
C	NC
D	NC
E	NC
F	NC
G	E0V
H	E5V
J	FG (Shield)
K	PS
L	$\overline{PS}$
M	NC
N	NC
P	NC
R	NC
S	BAT-
T	BAT+

Model code : AF320C157-P50-BA-XX



サーボモータ動力線ピン配置
Layouts of pins of the power & Brake line

A	ブレーキ (Brake)
B	ブレーキ (Brake)
C	NC
D	U相 (U Phase)
E	V相 (V Phase)
F	W相 (W Phase)
G	アース (Earth)
H	アース (Earth)
I	NC

サーボモータエンコーダ線ピン配置
Layouts of pins of the Absolute Encoder line

A	NC
B	NC
C	NC
D	NC
E	NC
F	NC
G	E0V
H	E5V
J	FG (Shield)
K	PS
L	PS
M	NC
N	NC
P	NC
R	NC
S	BAT-
T	BAT+

速度比 SPEED RATIO
157

Considering the use

This product features high precision and high rigidity, however, it is necessary to strictly comply with various restrictions and make appropriate to maximize the product's features. Please read this technical document thoroughly and select and adopt an appropriate model based on the actual operating environment, method, and conditions at your facility.

Export

- When this product is exported from Japan, it may be subject to the export regulations provided in the "Foreign Exchange Order and Export Trade Control Order". Be sure to take sufficient precautions and perform the required export procedures in advance if the final operating party is related to the military or the product is to be used in the manufacture of weapons, etc.

Application

- If failure or malfunction of the product may directly endanger human life or if it is used in units which may injure the human body (atomic energy facilities, space equipment, transportation equipment, medical equipment, safety units, etc.), examination of individual situations is required. Contact our agent or nearest business office in such a case.

Safety measures

- Although this product has been manufactured under strict quality control, a mistake in operation or misuse can result in breakdown or damage, or an accident resulting in injury or death. Be sure to take all appropriate safety measures, such as the installation of independent safeguards.

Product specifications indicated in this catalog

- The specifications indicated in this catalog are based on Nabtesco evaluation methods. This product should only be used after confirming that it is appropriate for the operating conditions of your system.

Operating environment

Use this product in the following environment:	Do not install the actuator at the following locations.
· Location where the ambient temperature is between 0°C and +40°C. · Location where the humidity is between 20% and 85% and no condensation occurs. · Location where the altitude is less than 1000 m. · Well-ventilated location	· Locations where a lot of dust is collected. · Outdoor areas that are directly affected by wind and rain · Locations near to areas that contain combustible, explosive, or corrosive gases and flammable materials. · Locations where the performance of the motor can be affected by magnetic fields or vibration. · Locations where significant vibration or shock is applied.

Note 1: **If the required operating environment cannot be established/met, contact us in advance.**
2: **When using the reduction gear under special conditions (clean room, equipment for food, concentrated alkali, high-pressure steam, etc.), contact our agent or nearest business office in advance.**

Maintenance

- The standard replacement time for lubricant is 20,000 hours. However, when operation involves a reduction gear surface temperature above 40°C, the state of degradation of the lubricant should be checked in advance of that and the grease replaced earlier as necessary.

Reduction gear temperature

- When the reduction gear is used under high load and at a high duty ratio, it may overheat and the surface temperature may exceed the allowable temperature. Be aware of conditions so that the surface temperature of the reduction gear does not exceed 60°C while it is in operation. There is a possibility of damage (to the product) if the surface temperature exceeds 60°C.

Actuator output rotation angle

- When the range of the rotation angle is small (10 degrees or less), the service life of the reduction gear may be reduced due to poor lubrication or the internal parts being subject to a concentrated load.

  Note: Contact us in case the rotation angle is 10 degrees or less.

Manuals

- Safety information and detail product instructions are indicated in the operation manual.
  The operation manual can be downloaded from the following website.
  http://precision.nabtesco.com/

Glossary

Rated torque

Calculated value with consideration of the motor rated torque, reduction speed ratio, and reduction gear efficiency.

Momentary maximum torque

Calculated value with consideration of the motor torque, reduction speed ratio, and reduction gear efficiency when the motor torque limit is set.

Rated output speed

Calculated value with consideration of the motor rated speed and reduction speed ratio.

Momentary maximum output speed

Calculated value with consideration of the motor maximum speed and reduction speed ratio.

Note: Be aware of cooling conditions so that the surface temperature of the reduction gear does not exceed 60°C during use.

Brake holding torque

Calculated value with consideration of the motor brake torque, reduction speed ratio, and reduction gear efficiency.

Note: The motor built-in brake is for holding the stop state. Do not use the brake to stop a moving load.

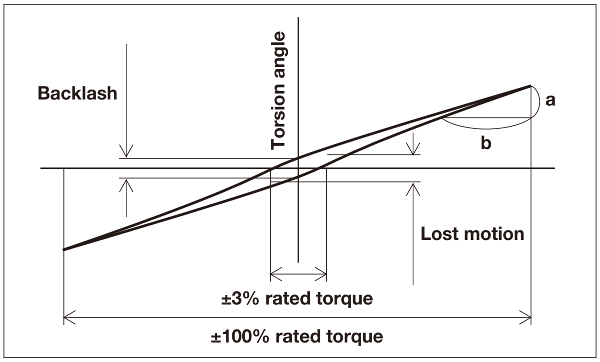
Duty ratio

The duty ratio is defined as the ratio of the sum of the total time of acceleration, constant speed, and deceleration to the cycle time of the actuator.

Torsional rigidity, lost motion, backlash

When a torque is applied to the output shaft while the input shaft is fixed, torsion is generated according to the torque value.
The torsion can be seen in the hysteresis curves.
The value of b/a is referred to as “torsional rigidity”.
The torsion angle at the mid point of the hysteresis curve width within ±3% of the rated torque is referred to as “lost motion”.
The torsion angle width of the hysteresis curve at zero torque is referred to as “backlash”.

<Hysteresis curve>

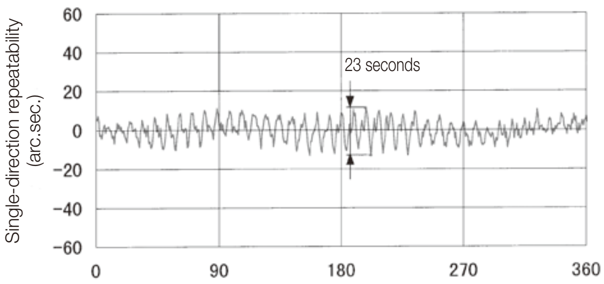


Allowable moment and maximum thrust load

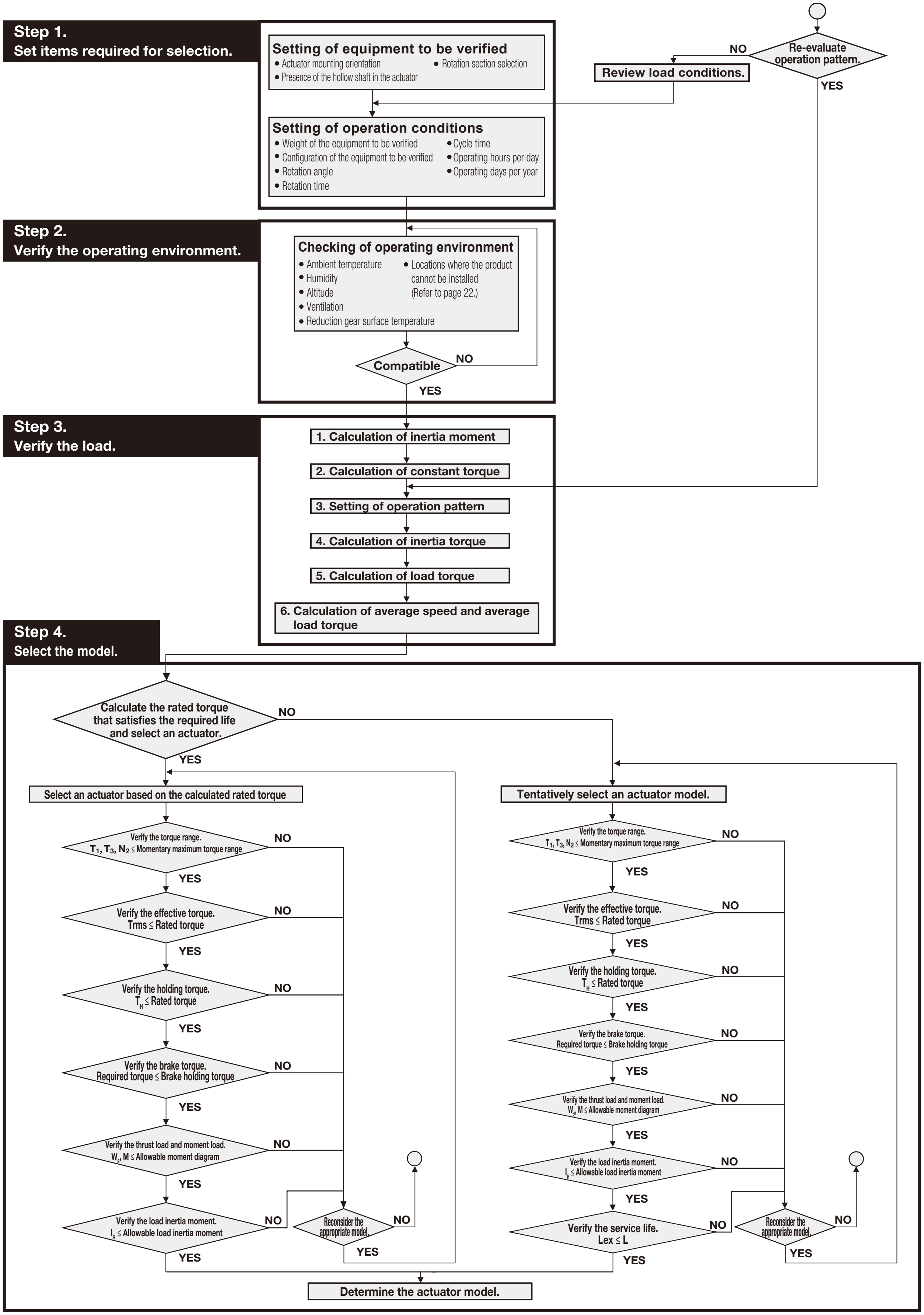
An external moment or thrust load may be applied to the reduction gear during normal operation.
The allowable values of the external moment and external axial load at this time are referred to as “allowable moment” and “maximum thrust load”.

Single-direction repeatability

The single-direction repeatability is defined as the difference between the theoretical output angle of rotation (when there are instructions input for an arbitrary rotation angle) and the actual output angle of rotation.



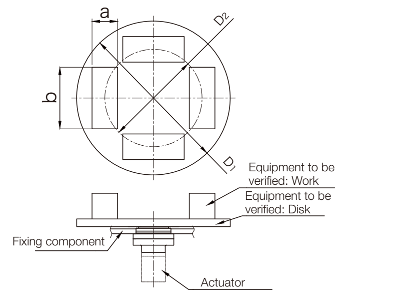
Product selection flowchart



Check that the regenerative energy calculated from the operation pattern is within the capacity of the regenerative resistor for the servo amplifier to be used. (Refer to page 31.)

Model code selection examples

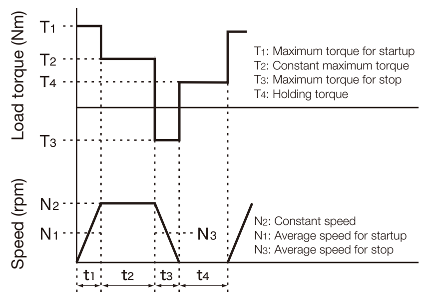
With horizontal rotational transfer



Step 1. Set the items required for selection.

Setting item	Setting
Reduction gear mounting direction Presence of the hollow shaft in the actuator Rotation section selection	Vertical shaft installation No hollow shaft type (Solid type) Shaft rotation direction when the case is fixed
Equipment weight to be considered	
W_A ———— Disk weight (kg)	180
W_B ———— Work weight (kg)	15 × 4 pieces
Equipment configuration to be considered	
D_1 ———— Disk: D dimension (mm)	1,200
a ———— Work piece: a dimension (mm)	100
b ———— Work piece: b dimension (mm)	300
D_2 ———— Work piece: P.C.D. (mm)	1,000
Operation conditions	
θ ———— Rotation angle (°)*1	180
$[t_1+t_2+t_3]$ —— Rotation time (s)	2.0
$[t_4]$ ———— Stop time (s)	5
Q_1 ———— Equipment operation hours per day (hours/day)	24
Q_2 ———— Equipment operation days per year (days/year)	365

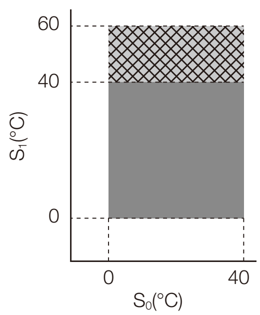
*1. When the range of the rotation angle is small (10 degrees or less), the rated life of the reduction gear may be reduced due to poor lubrication or internal parts being subject to a concentrated load.



Step 2. Verify the operating environment.

Checkpoint	Standard value
S_0 ———— Ambient temperature (°C)	0 to 40
S_1 ———— Reduction gear surface temperature (°C)	60 or less

Note: Refer to "Operating environment" on p. 22 for values other than those listed above.



Step 3-1. Verify the load.

Setting item		Calculation formula	Selection examples
(1) Calculate the inertia moment based the calculation formula on page 52.			
I_R	Load inertia moment (kgm^2)	$I_{R1}=\dfrac{W_A\times\left(\dfrac{D_1}{2\times1{,}000}\right)^2}{2}$ $I_{R2}=\left[\dfrac{W_B}{12}\left\{\left(\dfrac{a}{1{,}000}\right)^2+\left(\dfrac{b}{1{,}000}\right)^2\right\}+W_B\times\left(\dfrac{D_2}{2\times1{,}000}\right)^2\right]\times n$ I_{R1} = Disk inertia moment I_{R2} = Work inertia $I_R = I_{R1}+I_{R2}$ n = Number of work pieces	$I_{R1}=\dfrac{180\times\left(\dfrac{1{,}200}{2\times1{,}000}\right)^2}{2}$ $=32.4\ (kgm^2)$ $I_{R2}=\left[\dfrac{15}{12}\left\{\left(\dfrac{100}{1{,}000}\right)^2+\left(\dfrac{300}{1{,}000}\right)^2\right\}+15\times\left(\dfrac{1{,}000}{2\times1{,}000}\right)^2\right]\times4$ $=15.5(kgm^2)$ $I_R=32.4+15.5$ $=47.9\ (kgm^2)$
(2) Examine the constant torque.			
T_R	Constant torque (Nm)	$T_R=(W_A+W_B)\times9.8\times\dfrac{D_{in}}{2\times1{,}000}\times\mu$ μ = Friction factor Note: Use 0.015 for this example as the load is applied to the bearing of the RD2 precision reduction gear. D_{in}=Rolling diameter: See the following table. Note: If the actuator model is not determined, select the maximum value for D_{in}. Solid type: 232 (mm), Hollow shaft type: 351.5 (mm)	$T_R=(180+15\times4)\times9.8\times\dfrac{232}{2\times1{,}000}\times0.015$ $=4.1$ (Nm)

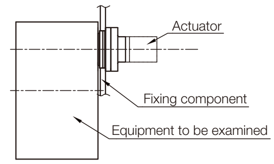
Model	AF 017N	AF 042N	AF 125N	AF 380N	AF 500N	AF 200C	AF 320C
Din	91	111	154	210	232	260	351.5

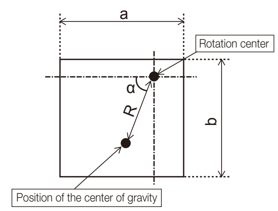
Setting item		Calculation formula	Selection examples
(3) Verify the load (horizontal direction).			
T_H	Holding torque (Nm)	0 for horizontal rotational transfer	T_H=0

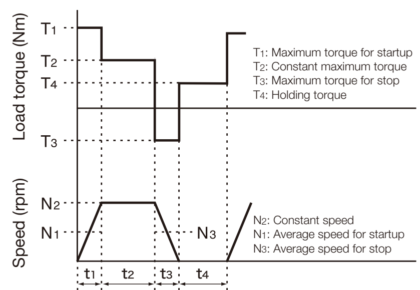
Step 3-2: Proceed to p. 27.

Model code selection examples

With vertical rotational transfer







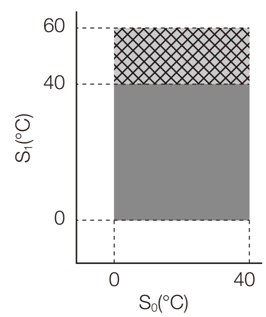
Step 1. Set the items required for selection.

Setting item		Setting
Reduction gear mounting direction		Horizontal shaft installation
Presence of the hollow shaft in the actuator		No hollow shaft type (Solid type)
Rotation section selection		Shaft rotation direction when the case is fixed
Equipment weight to be considered		
W_C	Mounted work weight (kg)	490
Equipment configuration to be considered		
a	a dimension (mm)	500
b	b dimension (mm)	500
R	R dimension (mm)	320
α	Angle α (°)	80
Operation conditions		
θ	Rotation angle (°)*1	90
$[t_1+t_2+t_3]$	Rotation time (s)	1.5
$[t_4]$	Stop time (s)	18.5
Q_1	Equipment operation hours per day (hours/day)	24
Q_2	Equipment operation days per year (days/year)	365

*1. When the range of the rotation angle is small (10 degrees or less), the rated life of the reduction gear may be reduced due to poor lubrication or internal parts being subject to a concentrated load.

Step 2. Verify the operating environment.

Checkpoint		Standard value
S_0	Ambient temperature (°C)	0 to 40
S_1	Reduction gear surface temperature (°C)	60 or less



Note: Refer to “Operating environment” on p. 22 for values other than those listed above.

Step 3-1. Verify the load.

Setting item		Calculation formula	Selection examples
(1) Calculate the inertia moment based the calculation formula on page 52.			
I_R	Load inertia moment (kgm^2)	$I_R=\frac{W_C}{12}\times\left\{\left(\frac{a}{1{,}000}\right)^2+\left(\frac{b}{1{,}000}\right)^2\right\}+W_C\times\left(\frac{R}{1{,}000}\right)^2$	$I_R=\frac{490}{12}\times\left\{\left(\frac{500}{1{,}000}\right)^2+\left(\frac{500}{1{,}000}\right)^2\right\}+490\times\left(\frac{320}{1{,}000}\right)^2$ $=70.6\,(kgm^2)$
(2) Examine the constant torque.			
T_R	Constant torque (Nm)	$T_R=W_C\times 9.8\times\frac{R}{1{,}000}$	$T_R=490\times 9.8\times\frac{320}{1{,}000}$ $=1{,}537\,(Nm)$
(3) Verify the load (vertical direction).			
T_H	Holding torque (Nm)	$T_H=W_C\times 9.8\times\frac{R}{1{,}000}\times\cos\alpha$ Applies to holding using a servo lock.	$T_H=490\times 9.8\times\frac{320}{1{,}000}\times\cos 80$ $=267\,(Nm)$

Step 3-2: Proceed to p. 27.
(Refer to “With horizontal rotational transfer” for selection examples.)

Step 3-2. Set items required for selection

Setting item	Calculation formula	Selection examples (With horizontal rotational transfer)
(3) Set the acceleration/deceleration time, constant-speed operation time, and output speed.		
t_1 — Acceleration time (s) t_2 — Constant-speed operation time (s) t_3 — Deceleration time (s) N_2 — Constant speed (min^{-1})	• The operation pattern does not need to be verified if it is already set. • If the operation pattern has not been determined, use the following formula to calculate the reference operation pattern. $N_2 = \dfrac{\theta}{3 \times (t_1 + 2 \times t_2 + t_3)}$ Note: 1. Enter a value that satisfies $t_1 = t_2 \leq (t_1 + t_2 + t_3)/2$. Note: 2. Assume that t_1 and t_3 are the same.	Assume that: $t_1 = t_3 = 0.5$ (s), $t_2 = 1.0$ (s) $N_2 = \dfrac{180}{3 \times (0.5 + 2 \times 1.0 + 0.5)}$ $= 20 (min^{-1})$
N_1 — Average speed for startup (min^{-1})	$N_1 = \dfrac{N_2}{2}$	$N_1 = \dfrac{20}{2} = 10$ (min^{-1})
N_3 — Average speed for stop (min^{-1})	$N_3 = \dfrac{N_2}{2}$	$N_3 = \dfrac{20}{2} = 10$ (min^{-1})
(4) Calculate the inertia torque for acceleration/deceleration.		
T_A — Inertia torque for acceleration (Nm)	$T_A = \left\{\dfrac{I_R \times (N_2 - 0)}{t_1}\right\} \times \dfrac{2\pi}{60}$	$T_A = \left\{\dfrac{47.9 \times (20 - 0)}{0.5}\right\} \times \dfrac{2\pi}{60}$ $= 200.6$ (Nm)
T_D — Inertia torque for deceleration (Nm)	$T_D = \left\{\dfrac{I_R \times (0 - N_2)}{t_3}\right\} \times \dfrac{2\pi}{60}$	$T_D = \left\{\dfrac{47.9 \times (0 - 20)}{0.5}\right\} \times \dfrac{2\pi}{60}$ $= -200.6$ (Nm)
(5) Calculate the load torque for acceleration/deceleration.		
T_1 — Maximum torque for startup (Nm)	$T_1 = \lvert T_A + T_R \rvert$ T_R: Constant torque With horizontal rotational transfer Refer to page 25 With vertical rotational transfer Refer to page 26	$T_1 = \lvert 200.6 + 4.1 \rvert$ $= 204.7$ (Nm)
T_2 — Constant maximum torque (Nm)	$T_2 = \lvert T_R \rvert$	$T_2 = 4.1$ (Nm)
T_3 — Maximum torque for stop (Nm)	$T_1 = \lvert T_A + T_R \rvert$ T_R: Constant torque With horizontal rotational transfer Refer to page 25 With vertical rotational transfer Refer to page 26	$T_3 = \lvert -200.6 + 4.1 \rvert$ $= 196.5$ (Nm)
T_4 — Holding torque (Nm)	$T_4 = \lvert T_H \rvert$ Applies to holding using a servo lock.	$T_4 = 0$
(6)-1 Calculate the average speed.		
N_m — Average speed (min^{-1})	$N_m = \dfrac{t_1 \times N_1 + t_2 \times N_2 + t_3 \times N_3}{t_1 + t_2 + t_3}$	$N_m = \dfrac{0.5 \times 10 + 1.0 \times 20 + 0.5 \times 10}{0.5 + 10 + 0.5}$ $= 15 (min^{-1})$
(6)-2 Calculate the average load torque.		
T_m — Average load torque (Nm)	$T_m = \sqrt[\frac{10}{3}]{\dfrac{t_1 \times N_1 \times T_1^{\frac{10}{3}} + t_2 \times N_2 \times T_2^{\frac{10}{3}} + t_3 \times N_3 \times T_3^{\frac{10}{3}}}{t_1 \times N_1 + t_2 \times N_2 + t_3 \times N_3}}$	$T_m = \sqrt[\frac{10}{3}]{\dfrac{0.5 \times 10 \times 204.7^{\frac{10}{3}} + 1.0 \times 20 \times 4.1^{\frac{10}{3}} + 0.5 \times 10 \times 196.5^{\frac{10}{3}}}{0.5 \times 10 + 1.0 \times 20 + 0.5 \times 10}}$ $= 144.3$ (Nm)

Go to page 28 if the actuator model is verified based on the required life.
Go to page 30 if the service life is verified based on the actuator model.

Model code selection examples

Step 4. Select an actuator

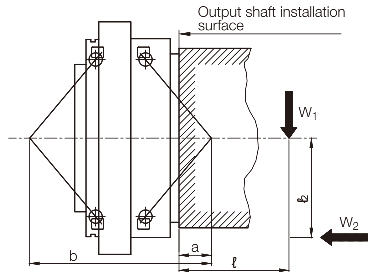
Actuator selection method (1) Calculate the required torque based on the load conditions and required life and select an actuator.

Setting/verification item		Calculation formula	Selection examples (With horizontal rotational transfer)
(1) Calculate the rated torque for the reduction gear that satisfies the required life.			
L_{ex}	Required life (year)	Based on the operation conditions	10 years
Q_{1cy}	Number of cycles per day (times)	$Q_{1cy}=\frac{Q_1\times60\times60}{t_1+t_2+t_3+t_4}$	$Q_{1cy}=\frac{24\times60\times60}{0.5+1+0.5+5}$ $=12{,}343$ (times)
Q_3	Operating hours of actuator per day (h)	$Q_3=\frac{Q_{1cy}\times(t_1+t_2+t_3)}{60\times60}$	$Q_3=\frac{12{,}343\times(0.5+1.0+0.5)}{60\times60}$ $=6.9$ (h)
Q_4	Operating hours of actuator per year (h)	$Q_4=Q_3\times Q_2$	$Q_4=6.9\times365$ $=2{,}519$ (h)
L_{hour}	Actuator service life (h)	$L_{hour}=Q_4\times L_{ex}$	$L_{hour}=2{,}519\times10$ $=25{,}190$ (h)
T_O'	Reduction gear rated torque that satisfies the required life (Nm)	$T_O'=T_m\times\left(\frac{10}{3}\right)\sqrt{\frac{L_{hour}}{\text{Reduction gear rated service life}}\times\frac{N_m}{\text{Reduction gear rated output speed}}}$ Note Reduction gear rated service life = 6,000 (h) Reduction gear rated output speed = 15 (min^{-1})	$T_O'=144.3\times\left(\frac{10}{3}\right)\sqrt{\frac{25{,}190}{6{,}000}\times\frac{15}{15}}$ $=221.9$ (Nm)
(2) Tentatively select a reduction gear model based on the calculated rated torque.			
Tentative selection of the actuator		Select an actuator for which the rated torque of the reduction gear [T_O'] is equal to or smaller than the rated torque of the reduction gear that satisfies the required life. See the following table for the reduction gear rated torque (it is different from the rated torque on page 12).	Tentatively select AF042N, which satisfies the following formula. [T_O'] 221.9 (Nm) ≤ Reduction gear rated torque 421 (Nm)

Frame number	AF 017N	AF 042N	AF 125N	AF 380N	AF 500N	AF 200C	AF 320C
Reduction gear rated torque (Nm)	166	412	1,225	3,724	4,900	1,960	3,136

Setting/verification item	Calculation formula	Selection examples (With horizontal rotational transfer)
(3) Verify the torque range.		
Verification of the torque range	Check that the load torque and operation pattern are within the momentary maximum torque range. Momentary maximum torque range: See page 13.	They are within the momentary maximum torque range. There is no problem with the tentatively selected model.
(4) Verify the effective torque.		
Verify the effective torque.	Check that the effective torque [Trms] is equal to or smaller than the rated torque. $T_{rms}=\sqrt{\frac{t1\times T1^2+t2\times T2^2+t3\times T3^2+t4\times T4^2}{t_1+t_2+t_3+t_4}}$	$T_{rms}=\sqrt{\frac{0.5\times204.7^2+1.0\times4.1^2+0.5\times196.5^2+5\times0^2}{0.5+1.0+0.5+5}}$ $=75.9$ (Nm) [Trms] 75.9 ≤ Rated torque 355 (Nm) There is no problem with the tentatively selected model.
(5) Verify the holding torque.		
Verification of the holding torque	Check that the holding torque [T_H] is equal to or smaller than the rated torque.	[T_H] 0 (Nm) ≤ Rated torque 355 (Nm) There is no problem with the tentatively selected model.
(6) Verify the brake holding torque.		
Verification of the brake holding torque.	If the actuator built-in brake is used for holding, check that the required brake torque is equal to or smaller than the brake holding torque.	

Actuator selection method (1) Calculate the required torque based on the load conditions and required life and select an actuator.

Setting/verification item	Calculation formula	Selection examples (With horizontal rotational transfer)
(6) Verify the thrust load and moment load.		
W_1 —— Radial load (N)		0 (N)
ℓ —— Distance to the point of radial load application (mm)		0 (mm)
W_2 —— Thrust load (N)		In this example, $W_2 = W_A + W_B = (180+20\times4)\times9.8$ $= 2{,}352$ (N) Note W_A, W_B : Refer to page 25.
ℓ_2 —— Distance to the point of thrust load application (mm)		0 (mm) (As the workpiece center is located on the rotation axis)
M —— Moment load (Nm)	$M = \frac{W_1\times(\ell + b - a) + W_2\times\ell_2}{1{,}000}$ a,b: Refer to the calculation of the tilt angle on page 32.	AF042N As dimension a = 29 (mm) and dimension b = 131.1 (mm): $M = \frac{0\times(0+131.1-29)+2{,}352\times0}{1{,}000}$ $= 0$ (Nm)
Verify the thrust load and moment load	Check that the thrust load and moment load are within the range in the allowable moment diagram on page 14. When radial load W_1 is applied within dimension b, use the reduction gear within the allowable radial load. If the tentatively selected reduction gear is outside of the specifications, change the reduction gear model.	For this example, Thrust load [W_2] = 2,352 (N) Moment load [M] = 0 (N) As the above values are within the range in the allowable moment diagram. There is no problem with the tentatively selected model.
(2) Verify the load inertia moment.		
Verify the load inertia moment.	Check that the load inertia moment [I_R] is equal to or smaller than the allowable load inertial moment.	[I_R] 47.9 (kgm^2) ≤ Allowable load inertia moment 51 (kgm^2) There is no problem with the tentatively selected model.

↓

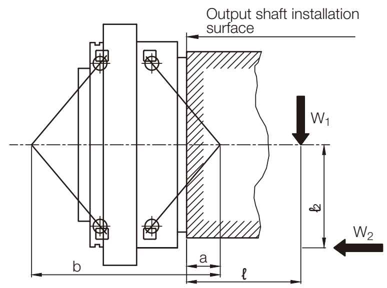
Select the actuator model that satisfies all the conditions of the above verification items.	Based on the above verification result, AF042N is selected.

Actuator selection method (2) Tentatively select an actuator model and evaluate the service life.

Setting/verification item	Calculation formula	Selection examples (With horizontal rotational transfer)
(1) Tentatively select a desired actuator model.		
Tentative selection of the actuator	Select a desired actuator model.	For example, tentatively select AF042N.
(2) Verify the torque range.		
Verification of the torque range	Check that the load torque and operation pattern are within the momentary maximum torque range. Momentary maximum torque range: See page 13.	They are within the momentary maximum torque range. There is no problem with the tentatively selected model.
(3) Verify the effective torque.		
Verify the effective torque.	Check that the effective torque [Trms] is equal to or smaller than the rated torque. $T_{rms} = \sqrt{\frac{t1\times T1^2 + t2\times T2^2 + t3\times T3^2 + t4\times T4^2}{t_1+t_2+t_3+t_4}}$	$T_{rms} = \sqrt{\frac{0.5\times204.7^2+1.0\times4.1^2+0.5\times196.5^2+5\times0^2}{0.5+1.0+0.5+5}}$ $=75.9$ (Nm) [Trms] 75.9 ≤ Rated torque 355 (Nm) There is no problem with the tentatively selected model.
(4) Verify the holding torque.		
Verification of the holding torque	Check that the holding torque [T_H] is equal to or smaller than the rated torque.	[T_H] 0 (Nm) ≤ Rated torque 355 (Nm) There is no problem with the tentatively selected model.
(5) Verify the brake holding torque.		
Verification of the brake holding torque.	If the actuator built-in brake is used for holding, check that the required brake torque is equal to or smaller than the brake holding torque.	

Model code selection examples

Reduction gear selection method (2): Tentatively select a reduction gear model and evaluate the service life.

Setting/verification item	Calculation formula	Selection examples (With horizontal rotational transfer)
(1) Verify the thrust load and moment load.		
W_1 —— Radial load (N)		0 (N)
ℓ —— Distance to the point of radial load application (mm)		0 (mm)
W_2 —— Thrust load (N)		$W_2 = W_A + W_B = (180 + 15 \times 4) \times 9.8 = 2{,}352$ (N)
ℓ_2 —— Distance to the point of thrust load application (mm)		0 (mm) (As the workpiece center is located on the rotation axis)
M —— Moment load (Nm)	$M = \frac{W_1 \times (\ell + b - a) + W_2 \times \ell_2}{1{,}000}$ a,b: Refer to the calculation of the tilt angle on page 32.	AF042N As dimension a = 29 (mm) and dimension b = 131.1 (mm): $M = \frac{0 \times (0 + 131.1 - 29) + 2{,}352 \times 0}{1{,}000} = 0$ (Nm)
Verify the thrust load and moment load	Check that the thrust load and moment load are within the range in the allowable moment diagram on page 14. When radial load W_1 is applied within dimension b, use the reduction gear within the allowable radial load. If the tentatively selected reduction gear is outside of the specifications, change the reduction gear model.	For this example, Thrust load [W_2] = 2,352 (N) Moment load [M] = 0 (N) As the above values are within the range in the allowable moment diagram. There is no problem with the tentatively selected model.
(2) Verify the load inertia moment.		
Verify the load inertia moment.	Check that the load inertia moment [I_R] is equal to or smaller than the allowable load inertial moment.	[I_R] 47.9 (kgm^2) ≤ Allowable load inertia moment 51 (kgm^2) There is no problem with the tentatively selected model.
(3) Verify the reduction gear service life.		
L_h —— Life (h)	$L_h = \text{Reduction gear rated service life} \times \frac{\text{Reduction gear rated speed}}{N_m} \times \left(\frac{\text{Reduction gear rated torque}}{T_m}\right)^{\frac{10}{3}}$ Reduction gear rated service life=6,000 (h) Reduction gear rated speed=15 (min^{-1}) Reduction gear rated torque=See the following table. (It is different from the rated torque on page 12.)	$L_h = 6{,}000 \times \frac{15}{15} \times \left(\frac{412}{144.3}\right)^{\frac{10}{3}} = 198{,}117$ (h)

Frame number	AF 017N	AF 042N	AF 125N	AF 380N	AF 500N	AF 200C	AF 320C
Reduction gear rated torque (Nm)	166	412	1,225	3,724	4,900	1,960	3,136

Setting/verification item	Calculation formula	Selection examples (With horizontal rotational transfer)
Q_{1cy} —— Number of cycles per day (times)	$Q_{1cy} = \frac{Q_1 \times 60 \times 60}{t_1 + t_2 + t_3 + t_4}$	$Q_{1cy} = \frac{24 \times 60 \times 60}{0.5 + 1.0 + 0.5 + 5} = 12.343$ (times)
Q_3 —— Operating hours per day (h)	$Q_3 = \frac{Q_{1cy} \times (t_1 + t_2 + t_3)}{60 \times 60}$	$Q_3 = \frac{12{,}343 \times (0.5 + 1.0 + 0.5)}{60 \times 60} = 6.9$ (h)
Q_4 —— Operating hours per year (h)	$Q_4 = Q_3 \times Q_2$	$Q_4 = 6.9 \times 365 = 2519$ (h)
L_{year} —— Reduction gear service life (year)	$L_{year} = \frac{L_h}{Q_4}$	$L_{year} = \frac{198{,}117}{2{,}519} = 78.6$ (year)
L_{ex} —— Required life (year)	Based on the operation conditions	10 years
Verification of the service life	Check the following condition: [L_{ex}] is equal to or less than [L_{year}] If the tentatively selected reduction gear is outside of the specifications, change the reduction gear model.	[L_{ex}] 10 (year) ≤ [L_{year}] 78.6 (year) There is no problem with the tentatively selected model.

↓

Select the actuator model that satisfies all the conditions of the above verification items.	Based on the above verification result, AF042N is selected.

Verification of the regenerative resistor capacity

The regenerative energy generated when the actuator decelerates is converted to heat by the regenerative register inside the servo amplifier.
Check that the regenerative energy calculated from the operation pattern is within the capacity of regenerative resistor for the servo amplifier to be used.
Contact Panasonic Corporation for the capacity of the regenerative resistor.

Setting/Verification items	Calculation formula
Verification of the regenerative resistor capacity	Check that the regenerative energy [W] is equal to or smaller than the servo amplifier capacity. Regenerative energy [W] = $\frac{T3 \times N1 \times 0.105 \times t3}{t1+t2+t3+t4}$ * When the regenerative energy exceeds the capacity, use an external regenerative resistor.

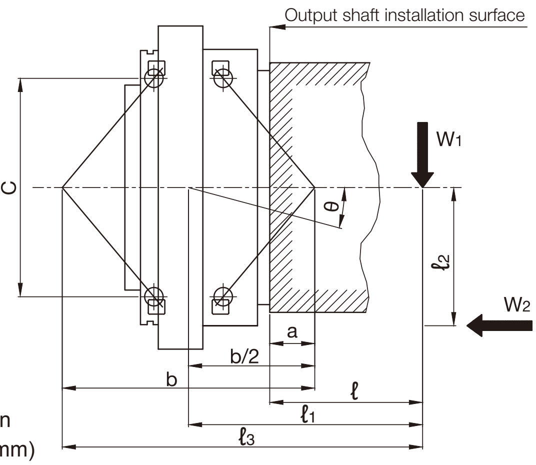
Calculation of tilt angle and torsion angle

Calculation of tilt angle

When a load moment occurs with an external load applied, the output shaft will tilt in proportion to the load moment (If ℓ_3 is larger than b, and ℓ_2 is larger than c/2)
The moment rigidity indicates the rigidity of the main bearing, and it is represented by the load moment value required for tilting the main bearing by 1 arc.min.

$$\theta = \frac{W_1\ell_1 + W_2\ell_2}{M_1 \times 10^3}$$

θ : Tilt angle of the output shaft (arc.min.)
M_1 : Moment rigidity (Nm/arc.min.)
W_1, W_2 : Load (N)
ℓ_1, ℓ_2 : Distance to the point of load application (mm)
ℓ_1 : $\ell + \frac{b}{2} - a$
ℓ : Distance from the output shaft installation surface to the point of load application (mm)



Model	Moment rigidity (central value) (Nm/arc.min.)	Dimensions (mm)		
		a	b	c
AF017N	515	22.1	112.4	91
AF042N	840	29	131.1	111
AF125N	1600	41.6	173.2	154
AF380N	5200	48.7	248.9	210
AF500N	6850	56.3	271.7	232

Model	Moment rigidity (central value) (Nm/arc.min.)	Dimensions (mm)		
		a	b	c
AF200C	9800	76	280.4	260
AF320C	12740	114.5	360.5	351.5

Calculation of torsion angle

Calculate the torsion angle when the torque is applied in a single direction, using an example of AF125N.

1) When the load torque is 30 Nm··················Torsion angle (ST_1)
   - When the load torque is 3% or less of the rated torque

$$ST_1 = \frac{\text{Load torque}}{\text{3\% of reduction gear rated torque}} \times \frac{\text{Lost motion}}{2} = \frac{30}{36.8} \times \frac{1}{2} = 0.40 \text{ (arc.min.) or less}$$

2) When the load torque is 1,300 Nm··················Torsion angle (ST_2)
   - When the load torque is more than 3% of the rated torque

$$ST_2 = \frac{\text{Lost motion}}{2} \times \frac{\text{Load torque - 3\% of reduction gear rated torque}}{\text{Torsional rigidity}} = \frac{1}{2} + \frac{1{,}000 - 36.8}{334} = 3.38 \text{ (arc.min.) or less}$$

Note: The torsion angles that are calculated above are for a single reduction gear.

Model	Torsional rigidity (central value) (Nm/arc.min.)	Lost motion		Backlash (arc.min.)
		Lost motion (arc.min.)	Measured torque (Nm)	
AF017N	36		±5.0	
AF042N	113		±12.4	
AF125N	334	1.0	±36.8	1.0
AF380N	948		±112.0	
AF500N	1,620		±147.0	

Model	Torsional rigidity (central value) (Nm/arc.min.)	Lost motion		Backlash (arc.min.)
		Lost motion (arc.min.)	Measured torque (Nm)	
AF200C	980	1.0	±58.8	1.0
AF320C	1,960		±94.1	

Design of actuator installation components

Installation of the actuator and mounting it to the output shaft

When installing the actuator, use hexagon socket head cap screws and tighten them at the torque specified below. The use of Serrated lock washers is recommended to prevent the hexagon socket head cap screws from loosening and to protect the seat surface from flaws.

• Hexagon socket head cap screw

<Bolt tightening torque and tightening force>

Model	Bolt connective component	Number of bolts - Size	Tightening torque (Nm)	Allowable transmission torque (Nm)	Bolt specification
AF017N	Shaft	8-M8	37.2 ± 1.86	934	Hexagon socket head cap screw JIS B 1176 : 2006 Strength class JIS B 1051 : 2000 12.9 Thread JIS B 0209 : 2001 6g
	Case	16-M5	9.01 ± 0.49	1,380	
AF042N	Shaft	9-M10	73.5 ± 3.43	2,185	
	Case	16-M6	15.6 ± 0.78	2,341	
AF125N	Shaft	21-M10	73.5 ± 3.43	6,872	
	Case	16-M10	73.5 ± 3.43	9,322	
AF380N	Shaft	33-M12	129 ± 6.37	25,787	
	Case	24-M12	129 ± 6.37	27,374	
AF500N	Shaft	33-M12	129 ± 6.37	30,002	
	Case	28-M12	129 ± 6.37	35,292	
AF200C	Shaft	9-M16	319 ± 15.9	13,542	
	Case	16-M12	129 ± 6.37	23,440	
AF320C	Shaft	15-M16	319 ± 15.9	34,203	
	Case	12-M16	319 ± 15.9	41,137	

Note: 1. The tightening torque values listed are for steel or cast iron material.
2. If softer material, such as aluminum or stainless steel, is used, limit the tightening torque. Also take the transmission torque and load moment into due consideration.

<Calculation of allowable transmission torque of bolts>

$$T = F \times \mu \times \frac{D}{2 \times 1{,}000} \times n$$

T	Allowable transmission torque by tightening bolt (Nm)
F	Bolt tightening force (N)
D	Bolt mounting P.C.D. (mm)
μ	Friction factor μ=0.15: When lubricant remains on the mating face. μ=0.20: When lubricant is removed from the mating face.
n	Number of bolts (pcs.)

• Serrated lock washer for hexagon socket head cap screw

Name: Belleville spring washer (made by Heiwa Hatsujyo Industry Co., Ltd.)

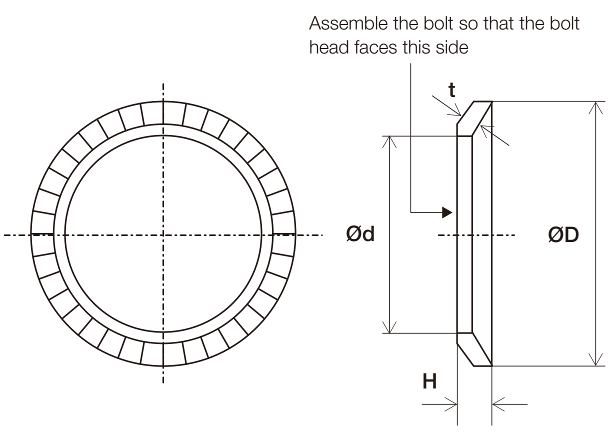
Corporation symbol: CDW-H
CDW-L (Only for M5)

Material: S50C to S70C

Hardness: HRC40 to 48

(Unit: mm)

Nominal size	ID and OD of Belleville spring washer		t	H
	Ød	ØD		
5	5.25	8.5	0.6	0.85
6	6.4	10	1.0	1.25
8	8.4	13	1.2	1.55
10	10.6	16	1.5	1.9
12	12.6	18	1.8	2.2
16	16.9	24	2.3	2.8



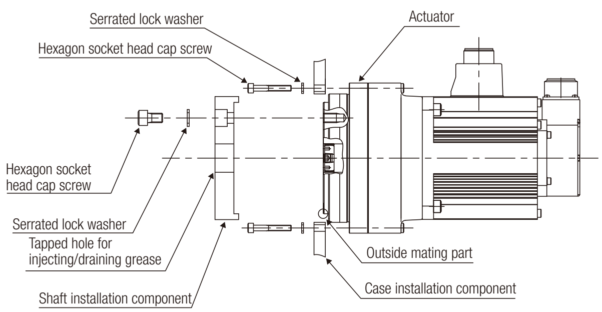
Note: When using any equivalent washer, select it with special care given to its outside diameter.

Design of actuator installation components

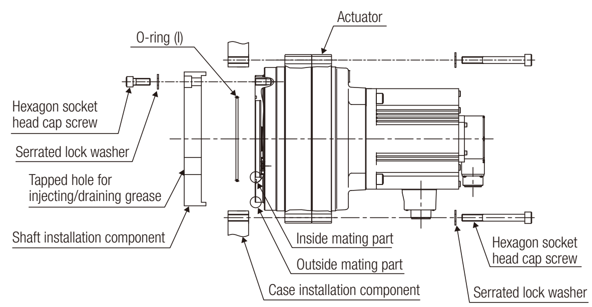
Align the case bolt holes (tapped holes) with the tapped holes (bolt holes) of the installation components, and the tapped holes of the shaft with the installation component bolt holes, and install the case with the designated number of bolts.
Use the specified tightening torque to uniformly tighten the hexagon socket head cap screws (with corresponding serrated lock washers).
Use either the outside or inside fit for the shaft.
After installing the actuator, we recommend the creation of a tapped hole for injecting/draining grease to enable lubricant replacement. An installation example is shown below.

Note: Always verify after installation that each bolt has been tightened at the specified torque.

• For AF017N, 042N, and 125N models



• For AF380N and 500N models



Suitable O-rings for O-Ring (I) in the diagram above are indicated in the following tables. Refer to these values when designing seals for the installation components.

• O-ring (I) JIS B 2401 : 2012

(Unit: mm)

Model	O-ring number	O-ring dimensions	
		Inside diameter	Width
AF380N	G145	Ø144.4	Ø3.1
AF500N	G185	Ø184.3	Ø5.7

If it is difficult to purchase any of the O-rings in the table to the left, select an O-ring based on the design standard of each manufacturer by referring to the dimensions listed to the left.

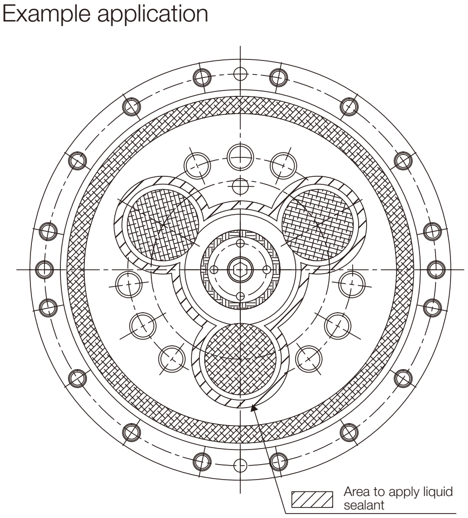
When AF017N, 042N or 125N model is used or if an O-ring cannot be used for structural reasons, seal the part by referring to the following instructions.

• Recommended liquid sealant

Refer to the diagram at right and apply the sealant so that it does not get inside the reduction gear and does not leak out of the shaft installation bolt hole.

Name (Manufacturer)	Characteristics and applications
ThreeBond 1211 (ThreeBond Co.)	• Silicone-based, solventless type • Semi-dry gasket
HermeSeal SS-60F (Nihon Hermetics Co.)	• One-part, non-solvent elastic sealant • Metal contact side (flange surface) seal • Any product basically equivalent to ThreeBond 1211
Loctite 515 (Henkel)	• Anaerobic flange sealant • Metal contact side (flange surface) seal

Example application



Note: 1. Do not use for copper or a copper alloy.
2. Contact us regarding use under special conditions (concentrated alkali, high-pressure steam, etc.)

Lubricant

The standard lubricant for the AF series is grease. The actuator is filled with our grease (RV GREASE LB00) before shipping.
When the actuator is operated with the appropriate amount of grease filled, the standard replacement time due to grease degradation is 20,000 hours. If the grease is dirty or the actuator is operated under poor ambient temperature conditions (40°C or higher), check the grease for any degradation or contamination and determine the replacement time.

<Approved grease brand>

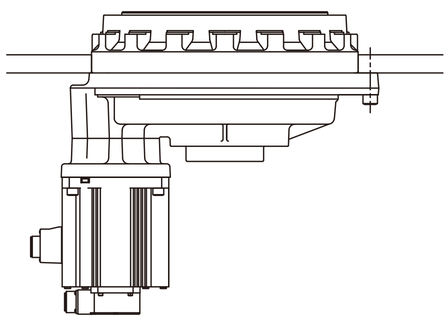
Brand	RV GREASE LB00
Manufacturer	Nabtesco Corporation
Ambient temperature	-10 to 40°C

<Amount of lubricant>

Model	Amount of lubricant (g)
AF017N	200
AF042N	335
AF125N	768
AF380N	1659
AF500N	1879
AF200C	2680
AF320C	4750

Installation orientation

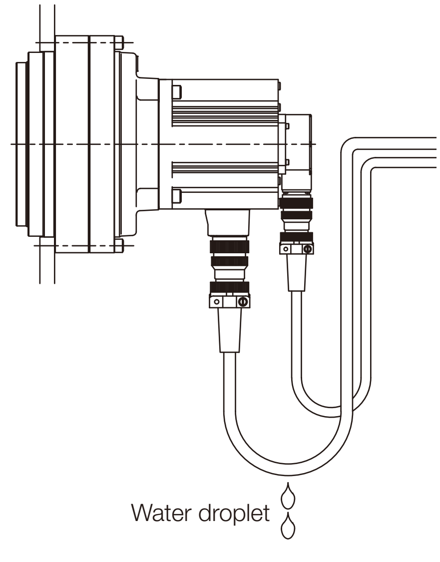
When using the hollow shaft type with the shaft facing upward and with the vertical shaft installed (see below), contact our service representative individually.
The solid type can be installed as shown below.



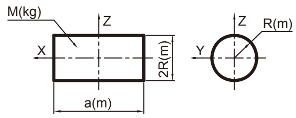
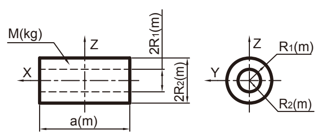
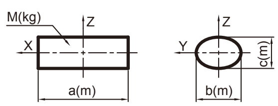
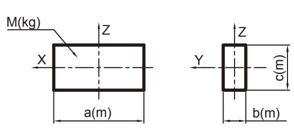
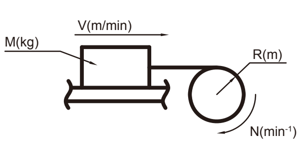
Vertical shaft installation
(with shaft facing upward)

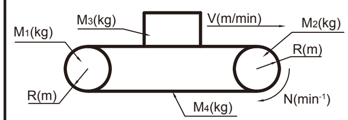
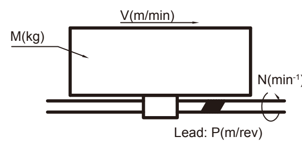
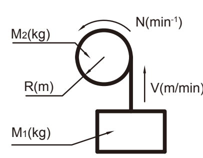
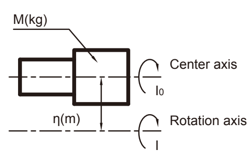
Note

- Keep this product away from areas with a large number of water or oil droplets. Do not let water or oil enter the connector through the wiring. If water or oil enters, it could cause damage to this product or an electric shock.
- Install the wires so that water or oil does not enter the connector. The wiring shown on the right can prevent water or oil droplets from entering the connector as they fall off the wiring.



Inertia moment calculation formula

Shape	I(kgm²)
1. Cylinder solid 	$I_x = \frac{1}{2}MR^2$ $I_y = \frac{1}{4}M\left(R^2+\frac{a^2}{3}\right)$ $I_z = I_y$
2. Cylinder hollow 	$I_x = \frac{1}{2}M\left(R_1^2+R_2^2\right)$ $I_y = \frac{1}{4}M\left\{\left(R_1^2+R_2^2\right)+\frac{a^2}{3}\right\}$ $I_z = I_y$
3. Oval cross section 	$I_x = \frac{1}{16}M\left(b^2+c^2\right)$ $I_y = \frac{1}{4}M\left(\frac{c^2}{4}+\frac{a^2}{3}\right)$ $I_z = \frac{1}{4}M\left(\frac{b^2}{4}+\frac{a^2}{3}\right)$
4. Rectangle 	$I_x = \frac{1}{12}M\left(b^2+c^2\right)$ $I_y = \frac{1}{12}M\left(a^2+c^2\right)$ $I_z = \frac{1}{12}M\left(a^2+b^2\right)$
5. General application 	$I = \frac{M}{4}\left(\frac{V}{\pi \times N}\right)^2 = MR^2$

Shape	I(kgm²)
6. Horizontal movement by conveyor 	$I = \left(\frac{M_1+M_2}{2}+M_3+M_4\right)\times R^2$
7. Horizontal movement by lead screw 	$I = \frac{M}{4}\left(\frac{V}{\pi \times N}\right)^2 = \frac{M}{4}\left(\frac{P}{\pi}\right)^2$
8. Up/down movement by hoist 	$I = M_1R^2 + \frac{1}{2}M_2R^2$
9. Parallel axis theorem 	$I = I_0 + M\eta^2$ I_0 : Moment of inertia of any object about an axis through its center of mass I : Moment of inertia about any axis parallel to the axis through its center of mass η : Perpendicular distance between the above two axes

Warranty

1. In the case where Nabtesco confirms that a defect of the Product was caused due to Nabtesco's design or manufacture within the Warranty Period of the Product, Nabtesco shall repair or replace such defective Product at its cost. The Warranty Period shall be from the delivery of the Product by Nabtesco or its distributor to you ("Customer") until the end of one (1) year thereafter, or the end of two thousand (2,000) hours running of the Product installed into Customer's equipment, whichever comes earlier.
2. Unless otherwise expressly agreed between the parties in writing, the warranty obligations for the Product shall be limited to the repair or replacement set forth herein. OTHER THAN AS PROVIDED HEREIN, THERE ARE NO WARRATIES ON THE PRODUCT, EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.
3. The warranty obligation under the Section 1 above shall not apply if:
   a) the defect was caused due to the use of the Product deviated from the Specifications or the working conditions provided by Nabtesco;
   b) the defect was caused due to exposure to foreign substances or contamination (dirt, sand etc.)
   c) lubricant or spare part other than the ones recommended by Nabtesco was used in the Product;
   d) the Product was used in an unusual environment (such as high temperature, high humidity, a lot of dust, corrosive/volatile/inflammable gas, pressurized/depressurized air, under water/liquid or others except for those expressly stated in the Specifications);
   e) the Product was disassembled, re-assembled, repaired or modified by anyone other than Nabtesco;
   f) the defect was caused due to the equipment into which the Product was installed;
   g) the defect was caused due to an accident such as fire, earthquake, lightning, flood or others; or
   h) the defect was due to any cause other than the design or manufacturing of the Product.
4. The warranty period for the repaired/replaced Product/part under the Section 1 above shall be the rest of the initial Warranty Period of the defective Product subjected to such repair/replace.

Rev. 002E

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CAT.151130 **(Issued on November 30, 2015)**