FANUC 9000kg 1-axis Positioner

MECHANICAL UNIT

OPERATOR'S MANUAL

B-84494EN/01

- **Original Instructions**

Thank you very much for purchasing FANUC Robot.
Before using the Robot, be sure to read the "FANUC Robot series SAFETY HANDBOOK (B-80687EN)" and understand the content.

The products in this manual are controlled based on Japan's "Foreign Exchange and Foreign Trade Law". The export from Japan may be subject to an export license by the government of Japan.
Further, re-export to another country may be subject to the license of the government of the country from where the product is re-exported. Furthermore, the product may also be controlled by re-export regulations of the United States government.
Should you wish to export or re-export these products, please contact FANUC for advice.

In this manual, we endeavor to include all pertinent matters. There are, however, a very large number of operations that must not or cannot be performed, and if the manual contained them all, it would be enormous in volume. It is, therefore, requested to assume that any operations that are not explicitly described as being possible are "not possible".

SAFETY PRECAUTIONS

This chapter describes the precautions which must be followed to enable the safe use of the robot. Before using the robot, be sure to read this chapter thoroughly.

For detailed functions of the robot operation, read the relevant operator's manual to understand fully its specification.

For the safety of the operator and the system, follow all safety precautions when operating a robot and its peripheral equipment installed in a work cell.
For safe use of FANUC robots, you must read and follow the instructions in the “FANUC Robot series SAFETY HANDBOOK (**B-80687EN)**”.

1 PERSONNEL

Personnel can be classified as follows.

Operator:
- Turns the robot controller power ON/OFF
- Starts the robot program from operator panel

Programmer or Teaching operator:
- Operates the robot
- Teaches the robot inside the safeguarded space

Maintenance technician:
- Operates the robot
- Teaches the robot inside the safeguarded space
- Performs maintenance (repair, adjustment, replacement)

- The operator is not allowed to work in the safeguarded space.
- The programmer or teaching operator and maintenance technician are allowed to work in the safeguarded space. Work carried out in the safeguarded space include transportation, installation, teaching, adjustment, and maintenance.
- To work inside the safeguarded space, the person must be trained on proper robot operation.

Table 1 (a) lists the work outside the safeguarded space. In this table, the symbol "O" means the work allowed to be carried out by the specified personnel.

Table 1 (a) List of work outside the Safeguarded Space

	Operator	Programmer or Teaching operator	Maintenance technician
Turn power ON/OFF to Robot controller	O	O	O
Select operating mode (AUTO/T1/T2)		O	O
Select remote/local mode		O	O
Select robot program with teach pendant		O	O
Select robot program with external device		O	O
Start robot program with operator's panel	O	O	O
Start robot program with teach pendant		O	O
Reset alarm with operator's panel		O	O
Reset alarm with teach pendant		O	O
Set data on teach pendant		O	O
Teaching with teach pendant		O	O
Emergency stop with operator's panel	O	O	O
Emergency stop with teach pendant	O	O	O
Operator's panel maintenance			O
Teach pendant maintenance			O

During robot operation, programming and maintenance, the operator, programmer, teaching operator and maintenance technician take care of their safety using at least the following safety protectors:

- Use clothes, uniform, overall adequate for the work
- Safety shoes
- Helmet

2 DEFINITION OF SAFETY NOTATIONS

To ensure the safety of users and prevent damage to the machine, this manual indicates each precaution on safety with "**WARNING**" or "**CAUTION**" according to its severity. Supplementary information is indicated by "**NOTE**". Read the contents of each **"WARNING"**, "**CAUTION**" and "**NOTE**" before using the robot.

Symbol	Definitions
⚠**WARNING**	Used if hazard resulting in the death or serious injury of the user will be expected to occur if he or she fails to follow the approved procedure.
⚠**CAUTION**	Used if a hazard resulting in the minor or moderate injury of the user, or equipment damage may be expected to occur if he or she fails to follow the approved procedure.
NOTE	Used if a supplementary explanation not related to any of WARNING and CAUTION is to be indicated.

3 WARNING & CAUTION LABEL

(1) Greasing and degreasing label

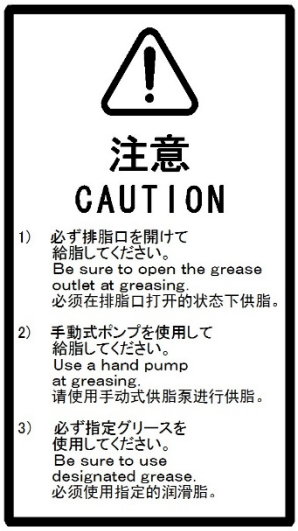


Fig. 3 (a) Greasing and degreasing label

Description

When greasing and degreasing, observe the instructions indicated on this label.

(a) Open the grease outlet at greasing.
(b) Use a hand pump at greasing.
(c) Use designated grease at greasing.

> ⚠ **CAUTION**
> See Chapter 7 ″CHECKS AND MAINTENANCE″ for explanations about specified grease, the grease amount, and the locations of grease and degrease outlets for individual models.

(2) Step-on prohibitive label

Fig. 3 (b) Step-on prohibitive label

Description

Do not step on or climb the robot or controller as it may adversely affect the robot or controller and you may get hurt if you lose your footing as well.

(3) High-temperature warning label

Fig. 3 (c) High-temperature warning label

Description

Be cautious about a section where this label is affixed, as the section generates heat. If you have to inevitably touch such a section when it is hot, use a protective provision such as heat-resistant gloves.

(4) Transportation label

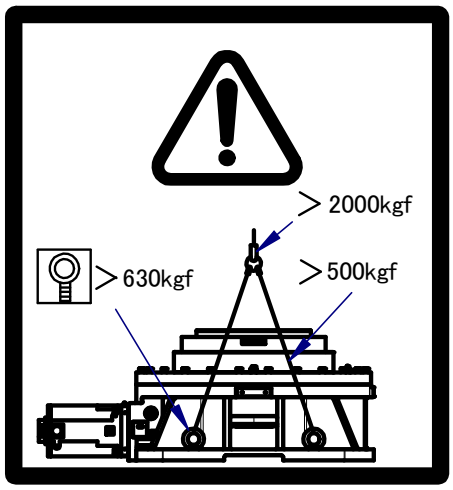


Fig. 3 (d) Transportation label

Description

When transporting the positioner, observe the instructions indicated on this label.

- Use a crane with a load capacity of 2000kg or greater.
- Use four slings with load capacity of 500 kg or greater.
- Use four eyebolts with each load capacity of 6174 N (630 kgf) or greater. (It is attached when the positioner is shipped.)

(5) Max. load capacity label

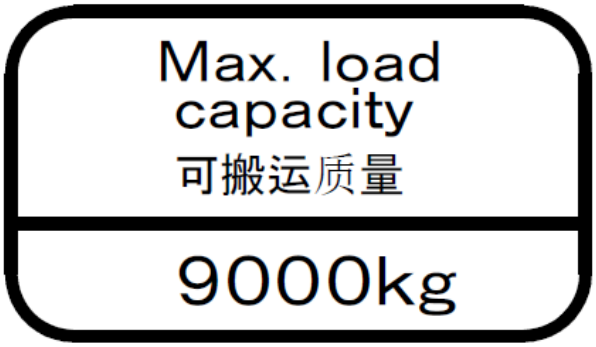


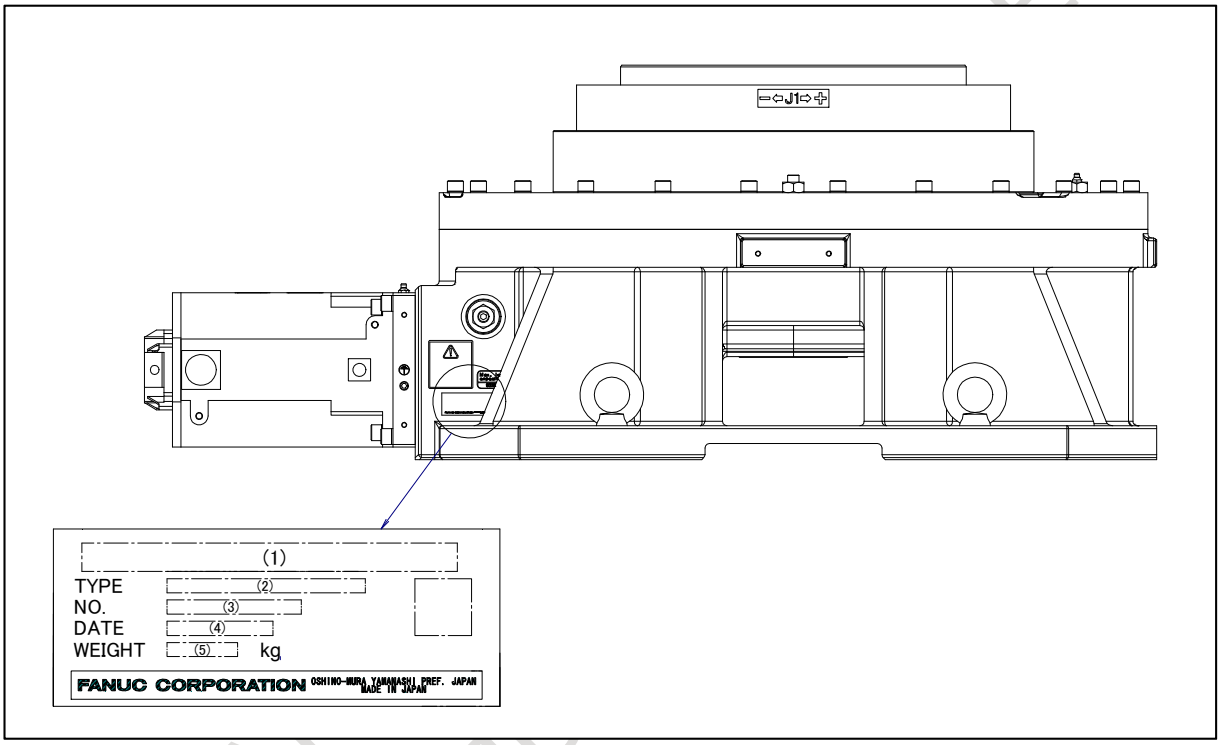
Fig. 3 (e) Max. load capacity label

PREFACE

This manual explains the operation procedures for the mechanical units of the following robots:

Model name	Mechanical unit specification No.	Maximum load
FANUC 9000kg 1-axis Positioner	A05B-1229-J601	9000kg

The label stating the mechanical unit specification number is affixed in the position shown below. Before reading this manual, verify the specification number of the mechanical unit.



Position of label indicating mechanical unit specification number

TABLE 1)

CONTENTS	(1) Model name	(2) TYPE	(3) No.	(4) DATE	(5) WEIGHT kg (Without controller)
LETTERS	FANUC 9000kg 1-axis Positioner	A05B-1229-J601	SERIAL NO. IS PRINTED	PRODUCTION YEAR AND MONTH ARE PRINTED	765

RELATED MANUALS

For the FANUC Robot series, the following manuals are available:

SAFETY HANDBOOK **B-80687EN** All persons who use the FANUC Robot and system designer must read and understand thoroughly this handbook		Intended readers: Operator, system designer Topics: Safety items for robot system design, operation, maintenance
R-30*i*B Plus/ R-30*i*B Mate Plus controller	OPERATOR'S MANUAL (Basic Operation) **B-83284EN** OPERATOR'S MANUAL (Alarm Code List) **B-83284EN-1** OPERATOR'S MANUAL (Optional Function) **B-83284EN-2** ARC WELDING FUNCTION OPERATOR'S MANUAL **B-83284EN-3** Spot WELDING FUNCTION OPERATOR'S MANUAL **B-83284EN-4** DISPENSE FUNCTION OPERATOR'S MANUAL **B-83284EN-5**	Intended readers: Operator, programmer, maintenance technician, system designer Topics: Robot functions, operations, programming, setup, interfaces, alarms Use: Robot operation, teaching, system design
	MAINTENANCE MANUAL **R-30*i*B Plus :** **B-83195EN** **R-30*i*B Mate Plus:** **B-83525EN**	Intended readers: Maintenance technician, system designer Topics: Installation, start-up, connection, maintenance Use: Installation, start-up, connection, maintenance

This manual uses following terms.

Name	Terms in this manual
Connection cable between positioner and controller	Positioner connection cable
Positioner mechanical unit	Mechanical unit

TABLE OF CONTENTS

1 TRANSPORTATION AND INSTALLATION

1.1 TRANSPORTATION

Use a crane to transport the positioner. When transporting the positioner, lift it by using the eyebolts to the specified position.

> **⚠ CAUTION**
> When lifting the positioner, be careful not to damage motors, connectors, or cables of the positioner by slings.

> **⚠ WARNING**
> 1 When hoisting or lowering the positioner with a crane or forklift, move it slowly, and with great care. When placing the positioner on the floor, exercise care to prevent the installation surface of the positioner from striking the floor.
> 2 The positioner becomes unstable when it is transported with the end effector or equipment is installed. Make sure to remove the end effector when the positioner is transported.
> 3 Before moving the positioner by using crane, check and tighten any loose bolts on the forklift pockets.
> 4 Do not pull eyebolts sideways.

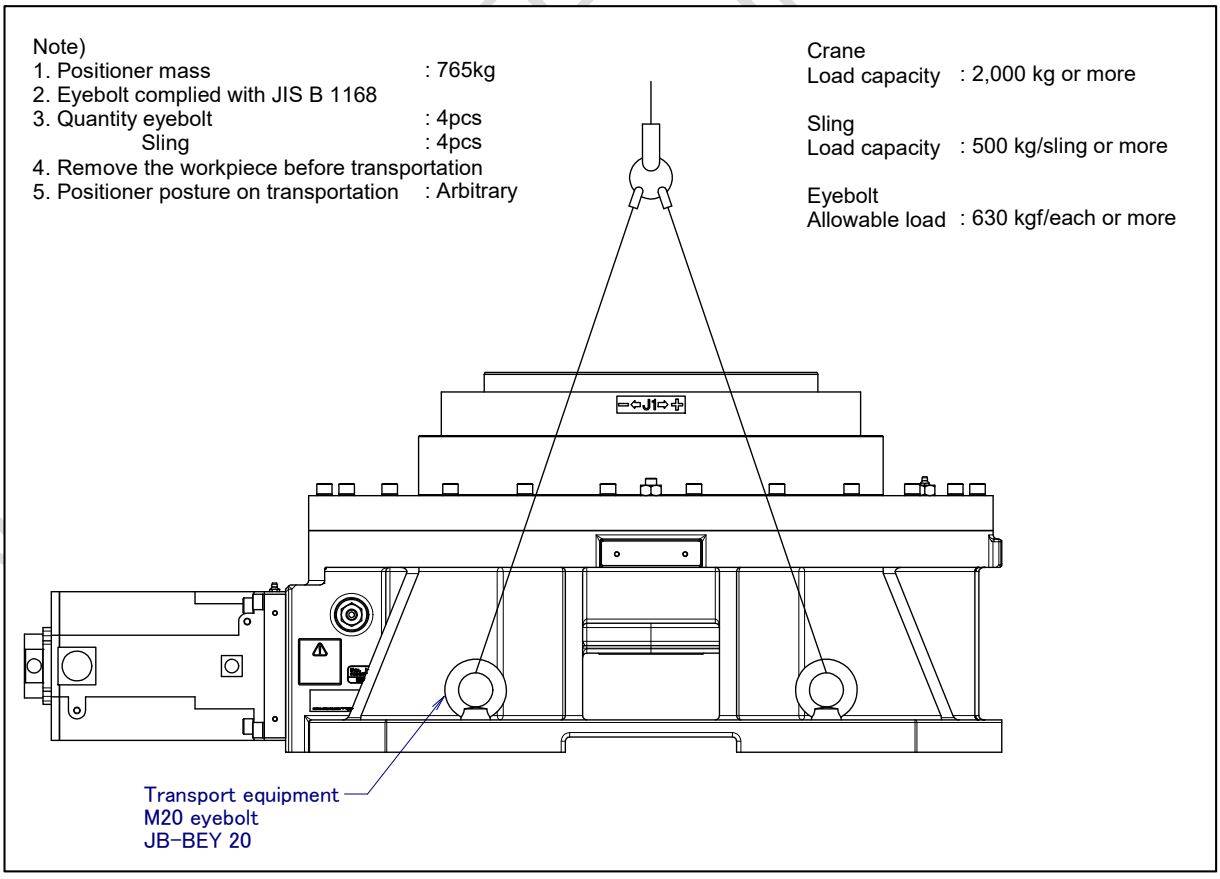


Fig. 1.1 (a) Transportation using a crane

1.2 INSTALLATION

Fig. 1.2 (a) shows the dimensions of the positioner base.

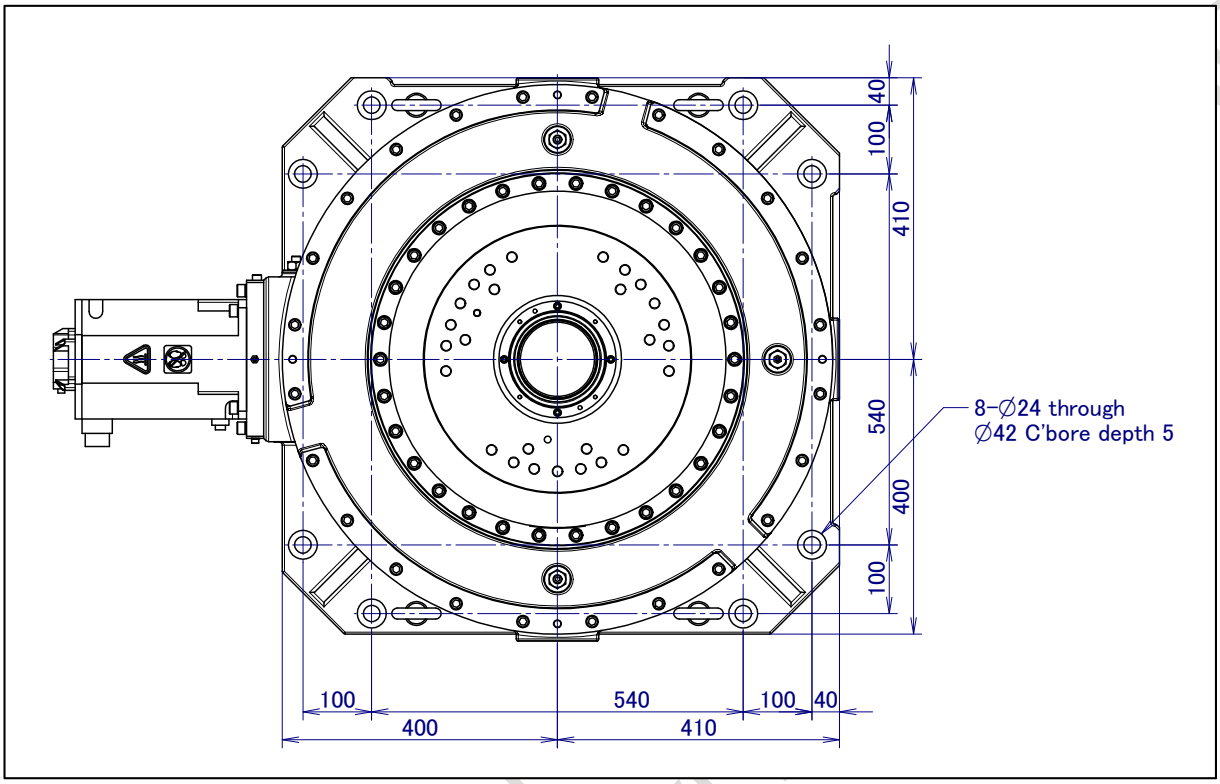


Fig. 1.2 (a) Dimensions of the positioner base

1.2.1 Installation Method

Fig. 1.2.1 (a) shows examples of installing the positioner.

NOTE
The customer shall prepare for the positioning pin, anchor bolts, and floor plate.

In this example, the floor plate is fixed with twelve M20 chemical anchors (Tensile strength 400N/mm^2 or more), and the positioner base is fastened to the floor plate with eight M20 x 65 bolts (Tensile strength 1200N/mm^2 or more).
When compatibility must be maintained in teaching the positioner mechanical unit replacement, use the locating surface.

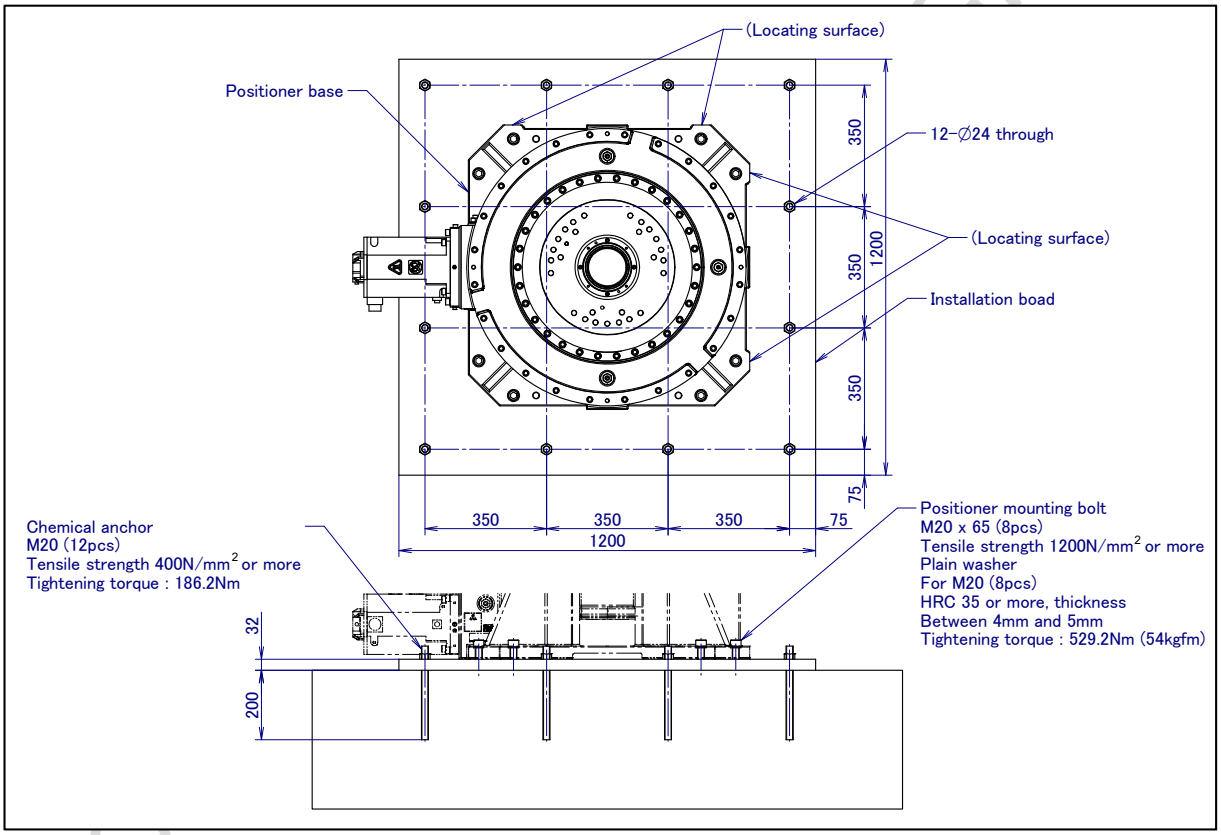


Fig. 1.2.1 (a) Example of installing the positioner

NOTE
Flatness of positioner installation surface must be less than or equal to 0.5mm.
If positioner base is placed on uneven ground, it may result in the base breakage or low performance of the positioner.

Refer to Table 1.2.1 (a) about size of bolt, number, and tightening torque of the positioner main body.

Table 1.2.1 (a) Base mounting bolts of positioner

Model	9000kg 1-axis Positioner
Mounting bolt	M20
Q'ty	8
Tightening torque [Nm]	529.2

Fig. 1.2.1 (b) and Table 1.2.1 (b) show the force and moment applied to the Robot base when the maximum work is installed. Refer to the data when considering the strength of the installation face.

Table 1.2.1 (b) Force and moment that act on base (A05B-1229-J601)

	Vertical moment M_V [kNm](kgfm)	**Force in vertical direction F_V [kN] (kgf)**	**Horizontal moment M_H [kNm] (kgfm)**	**Force in horizontal direction F_H [kN] (kgf)**
During stillness	25.58 (2610.00)	95.70 (9765.00)	0 (0)	0 (0)
During acceleration or deceleration	25.58 (2610.00)	95.70 (9765.00)	9.23 (942.30)	2.10 (214.54)
During Power-Off stop	25.58 (2610.00)	95.70 (9765.00)	40.77 (4160.22)	10.93 (1115.59)

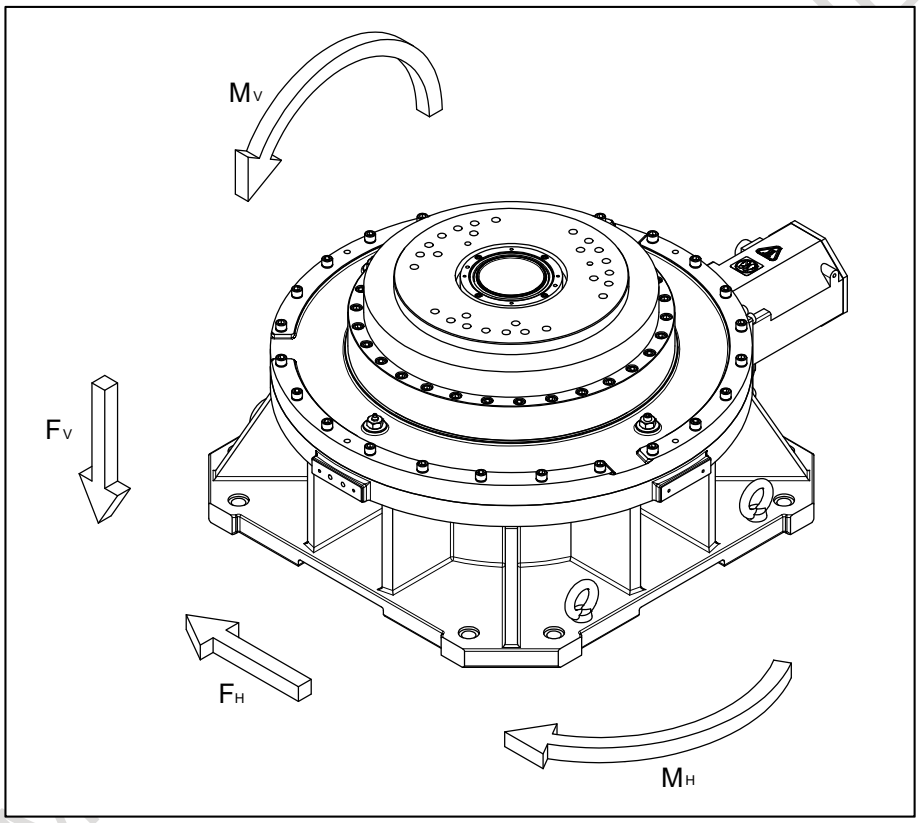


Fig. 1.2.1 (b) Force and moment that acts on base

1.3 MAINTENANCE AREA

Fig. 1.3 (a) shows the maintenance area of the mechanical unit.

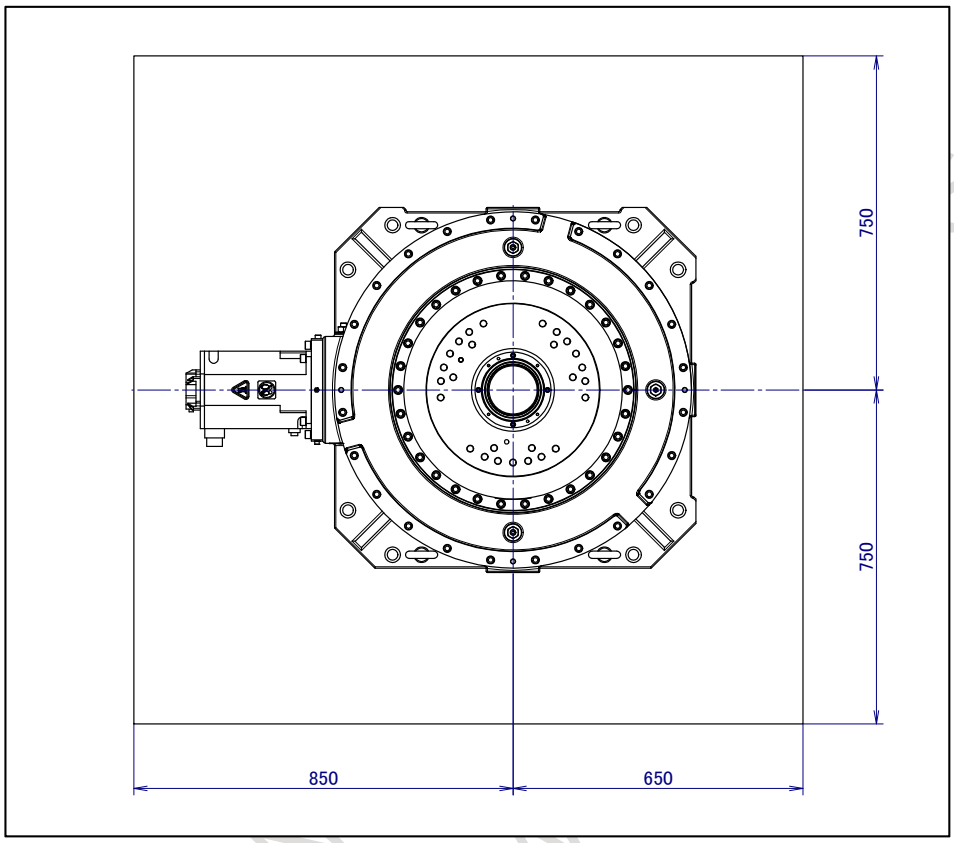


Fig. 1.3 (a) Maintenance area

1.4 INSTALLATION CONDITIONS

Refer to specification of Section 3.1 about installation conditions.

2 CONNECTION WITH THE CONTROLLER

The robot is connected with the controller via the power and signal cable and earth cable.
Positioner connection cable is removed from the positioner when shipped. (The controller side cable is connected.) When the Connector option A05B-1229-J631 (below, Connector option) is not specified, connect the motor direct connection cable to the connector of the motor. When the connector option is specified, connect each cable to the connector part of the robot backside. (See Fig. 2 (a)) Pay attention not to pull the cables when connecting.
For cable laying between the robot controller and the positioner main body, prepare tools such as a cable duct by customers.
See Table 2 (a) for the controllers and servo amplifiers that can be connected to the positioner.

Table 2 (a) Controllers and servo amplifiers

Controller	Servo amplifier	Specification No.
R-30*i*B / R-30*i*B Plus	α*i*SV 160	A05B-2605-J040#H106
	α*i*SV 80/160	A05B-2605-J040#H210
	α*i*SV 160/160	A05B-2605-J040#H211

⚠ WARNING
Before turning on controller power, be sure to connect the positioner and controller with the earth line (ground). Otherwise, there is the risk of electrical shock.

⚠ CAUTION
1 Before connecting the cables, be sure to turn off the controller power.
2 Don’t use 10m or longer coiled cable without first untying it. The long coiled cable could heat up and become damaged.

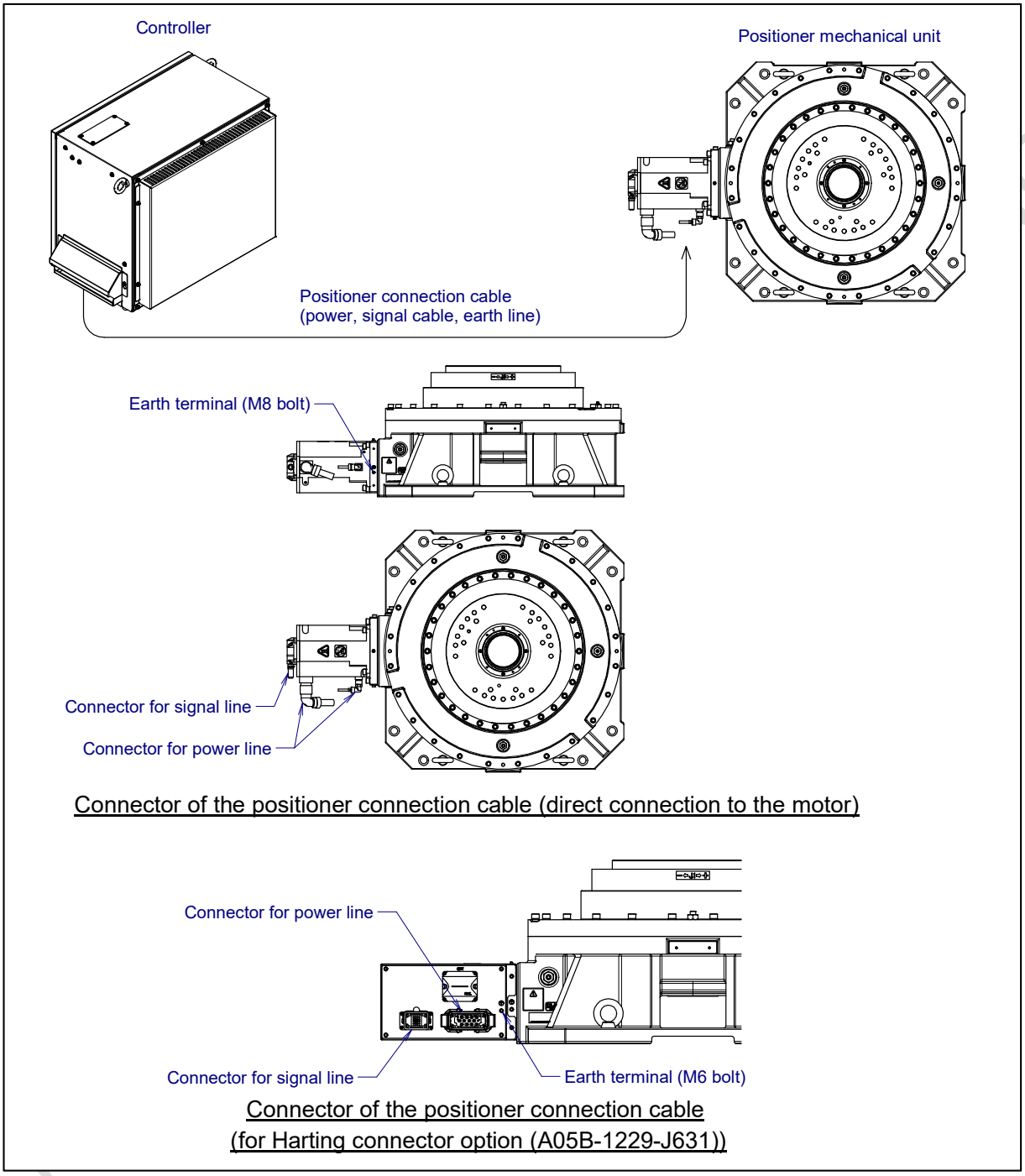


Fig. 2 (a) Cable connection

3 BASIC SPECIFICATIONS

3.1 POSITIONER CONFIGURATION

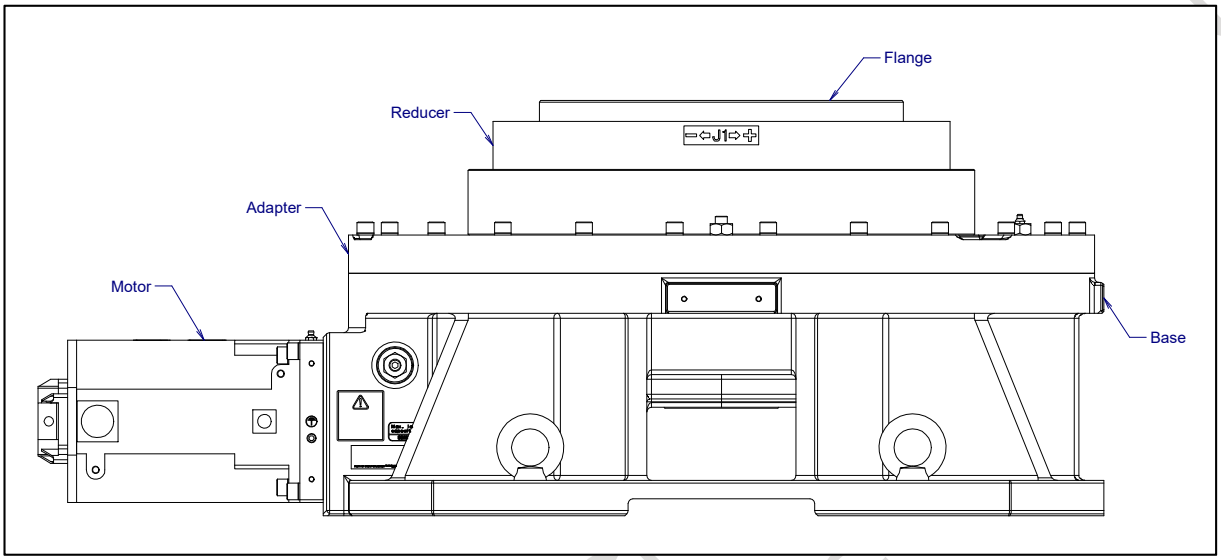


Fig. 3.1 (a) Mechanical unit configuration

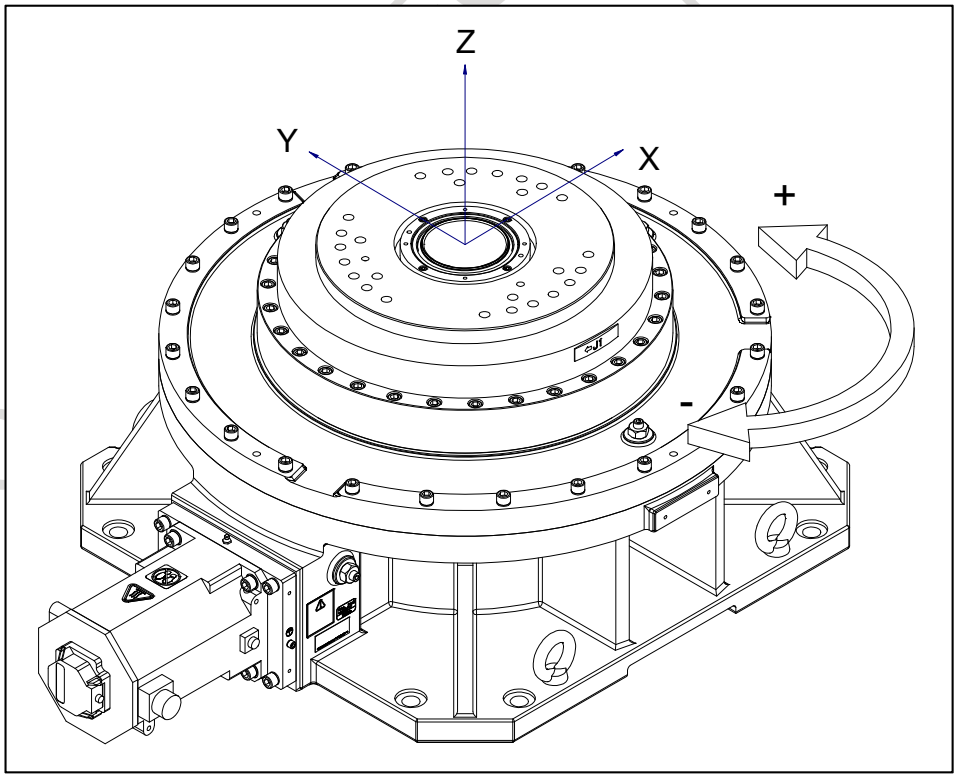


Fig. 3.1 (b) Mechanical interface coordinates

NOTE
The end effector mounting face center is (0, 0, 0) of the mechanical interface coordinates.

Specifications

Item	Specifications	
Model	9000kg 1-axis Positioner	
Installation	Floor	Wall mount
Motion range	370°(-185° to +185°) 6.46 rad (-3.23rad to +3.23rad) Continuous rotation is available. (NOTE 1)	
Maximum operation speed (NOTE 2)	60°/sec 1.05 rad/sec	
Max. load capacity	9000 kg	
Allowable load moment	9000 kgf·m 88200 N·m	648 kgf·m 6350 N·m
Allowable bending moment	4500 kgf·m 44100 N·m	
Allowable load inertia	102041 kgf·cm·s^2 10000 kg·m^2	71429 kgf·cm·s^2 7000 kg·m^2
Repeatability (NOTE 3)	±0.02mm (R=500)	
Drive method	Electric servo drive by AC servo motor	
Mass	About 765 kg	
Installation environment	Ambient temperature : 0 - 45°C Ambient humidity (NOTE 4) Normally : 75%RH or less (No dew or frost allowed) Short time (within 1 month) 95%RH or less (No dew or frost allowed) Vibration acceleration : 4.9m/s^2 (0.5G) or less Free of corrosive gases (NOTE 5)	

NOTE

1 Continuous rotation function A05B-2600-J613 must be ordered. Please refer to the manual (B-83284JA-2).
2 During short distance motions, the axis speed may not reach the maximum value stated.
3 Compliant with ISO9283.
4 When the robot is used in a low temperature environment that is near to 0ºC, or not operated for a long time in the environment that is less than 0ºC (during a holiday or during the night), a collision detection alarm (SRVO-050) etc. may occur since the resistance of the drive mechanism could be high immediately after starting the operation. In this case, we recommend performing the warm up operation for several minutes.
5 Contact the service representative, if the positioner is to be used in an environment or a place subjected to hot/cold temperatures, severe vibrations, heavy dust, cutting oil splash and or other foreign materials.

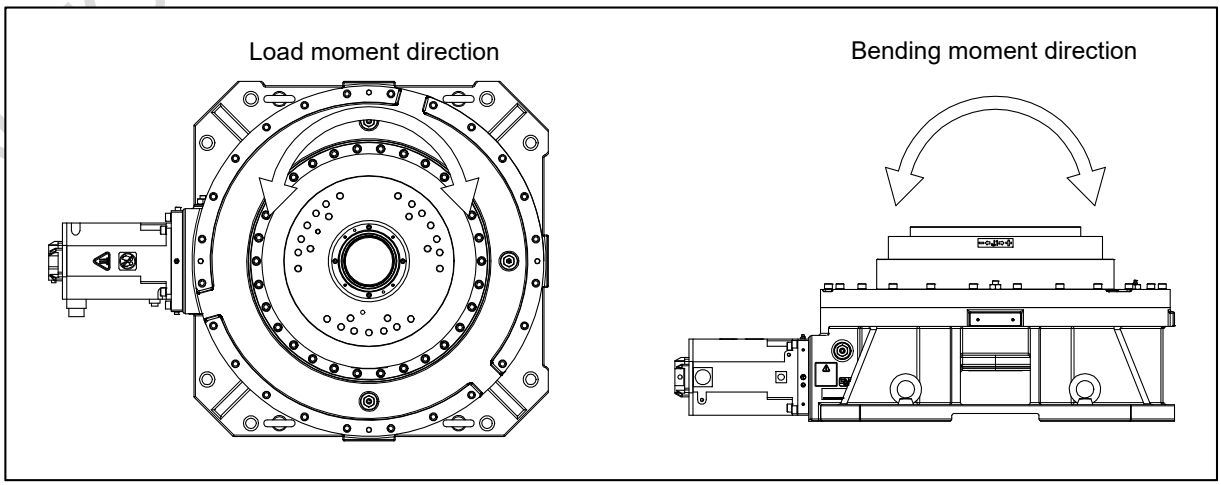


Fig. 3.1 (c) Direction of moment

Dustproof and waterproof characteristics

	Normal specification
Mechanical unit	IP54

NOTE
Definition of IP 54
5= Dust-tight: Ingress of dust is not entirely prevented, but it must not enter in sufficient quantity to interfere with the satisfactory of the equipment.
4= Protection from water immersion: Water splashing against the enclosure from any direction shall have no harmful effect.

(1) The positioner (including severe dust/liquid protection model) cannot be used with the following liquids. Potentially these liquids will cause irreversible damage to the rubber parts (such as: gaskets, oil seals, O-rings etc.). (As exception to this only liquids tested and approved by FANUC can be used with the positioner.)
   (a) Organic solvents
   (b) Cutting fluid or cleaning fluid including chlorine / gasoline
   (c) Amine type cutting fluid or cleaning fluid
   (d) Acid, alkali and liquid causing rust
   (e) Other liquids or solutions, that will harm NBR or CR rubber
(2) When the positioners work in the environment, using water or liquid, complete draining of J1 base must be done. Incomplete draining of J1 base will make the positioner break down.
(3) Don not use unconfirmed cutting fluid and cleaning fluid.
(4) Do not use the positioner immersed in water, neither temporary nor permanent. Positioner must not be wet permanently.
   *Example : in case motor surface is exposed to water for a long time, liquid may invade inside the motor and cause failure.

Option parts

The following options are prepared for the positioner.

Option spec	Option name	Function
A05B-1229-J611	Clamp option	Cable clamp is attached to the positioner mechanical unit.
A05B-1229-J621	Motor cover option	Cover is attached to the motor.
A05B-1229-J631	Connector option	Positioner connector cable is changed to the Haring connector.
A05B-1229-J641	Signal cable continuous rotation option	Continuous rotation of signal cable and air supply for additional equipment is possible.
A05B-1229-J651	Flange option	Flange plate is attached to the upper surface of the reducer.

3.2 EXTERNAL DIMENSIONS OF THE MECHANICAL UNIT

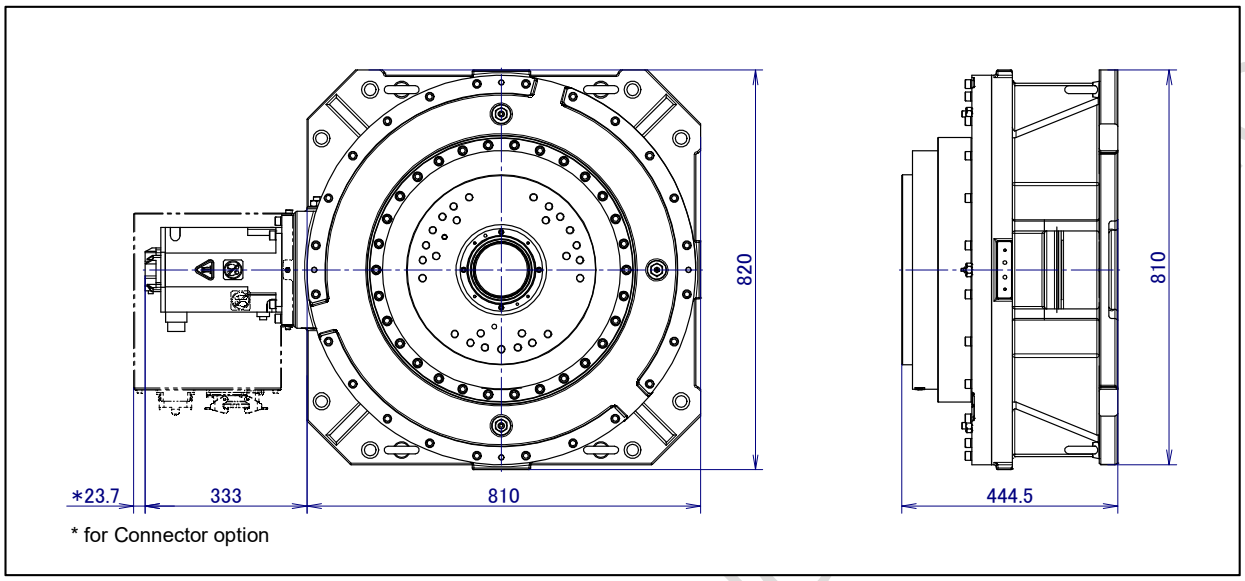


Fig. 3.2 (a) External dimensions of the positioner

3.3 ZERO POINT POSITION AND MOTION LIMIT

Zero point and motion range are provided for each controlled axis. Exceeding the software motion limit of a controlled axis is called overtravel (OT). Overtravel is detected at both ends of the motion limit for each axis. The positioner cannot exceed the motion range unless there is a loss of zero point position due to abnormalities in servo system or system error.

Fig. 3.3 (a) shows the zero point and motion limit.

* The motion range can be changed. For information on how to change the motion range, see Chapter 6, “AXIS LIMIT SETUP”.

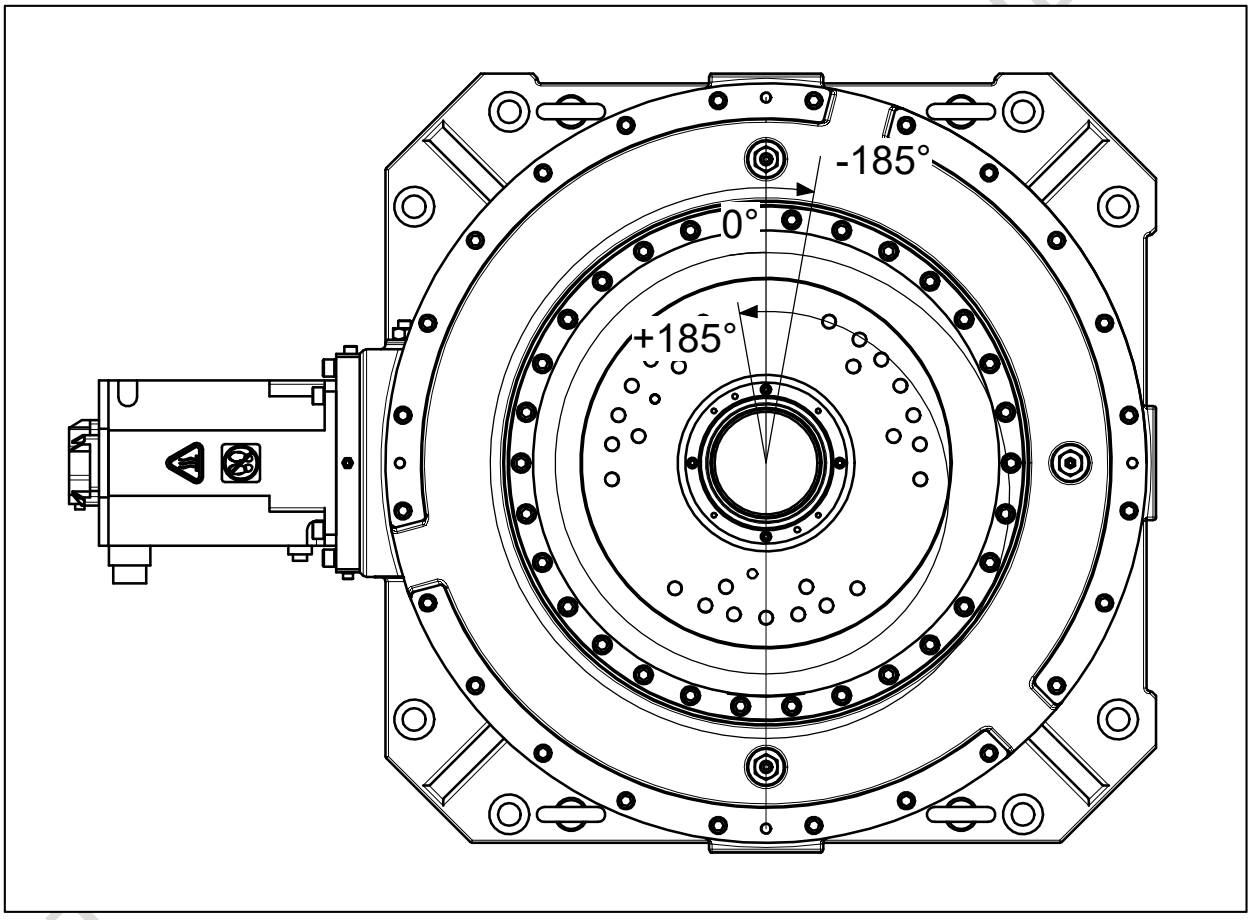


Fig. 3.3 (a) J1-axis motion limit

3.4 POSITIONER LOAD CONDITIONS

Fig. 3.4 (a) and (b) are diagrams showing the allowable load that can be applied to the positioner section.

- Apply a load within the region indicated in the graph.
- Apply the conditions of the allowable load moment and the allowable load inertia. See Section 3.1 about the allowable load moment and the allowable load inertia.
- See Section 4.1 about mounting of end effector.

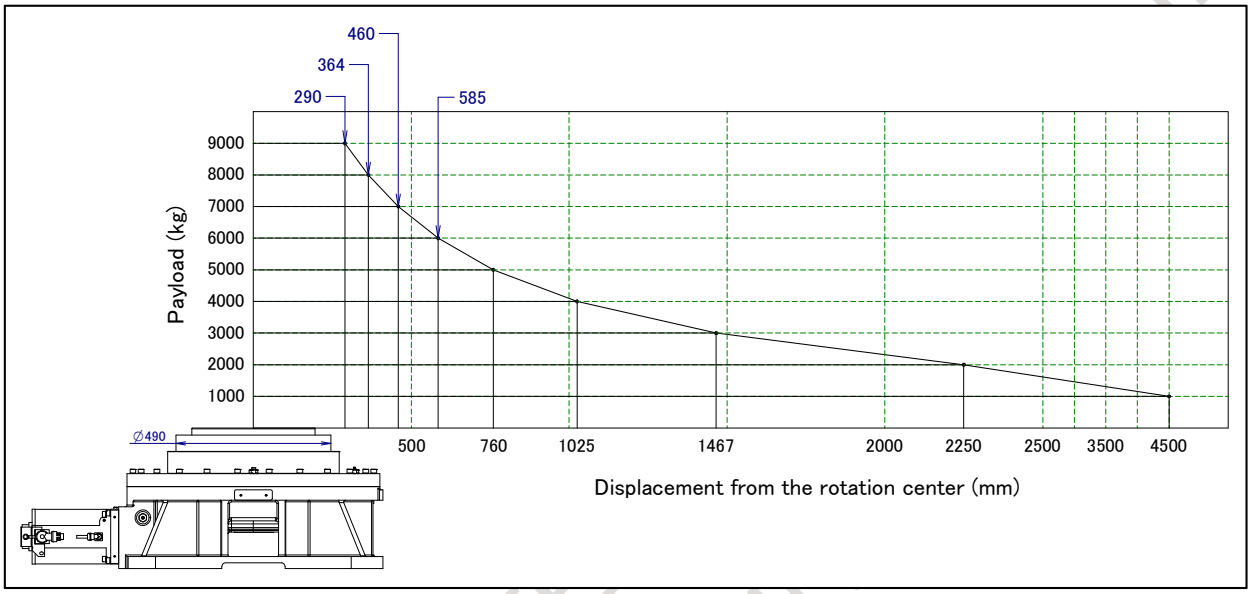


Fig. 3.4 (a) Load diagram for floor installation

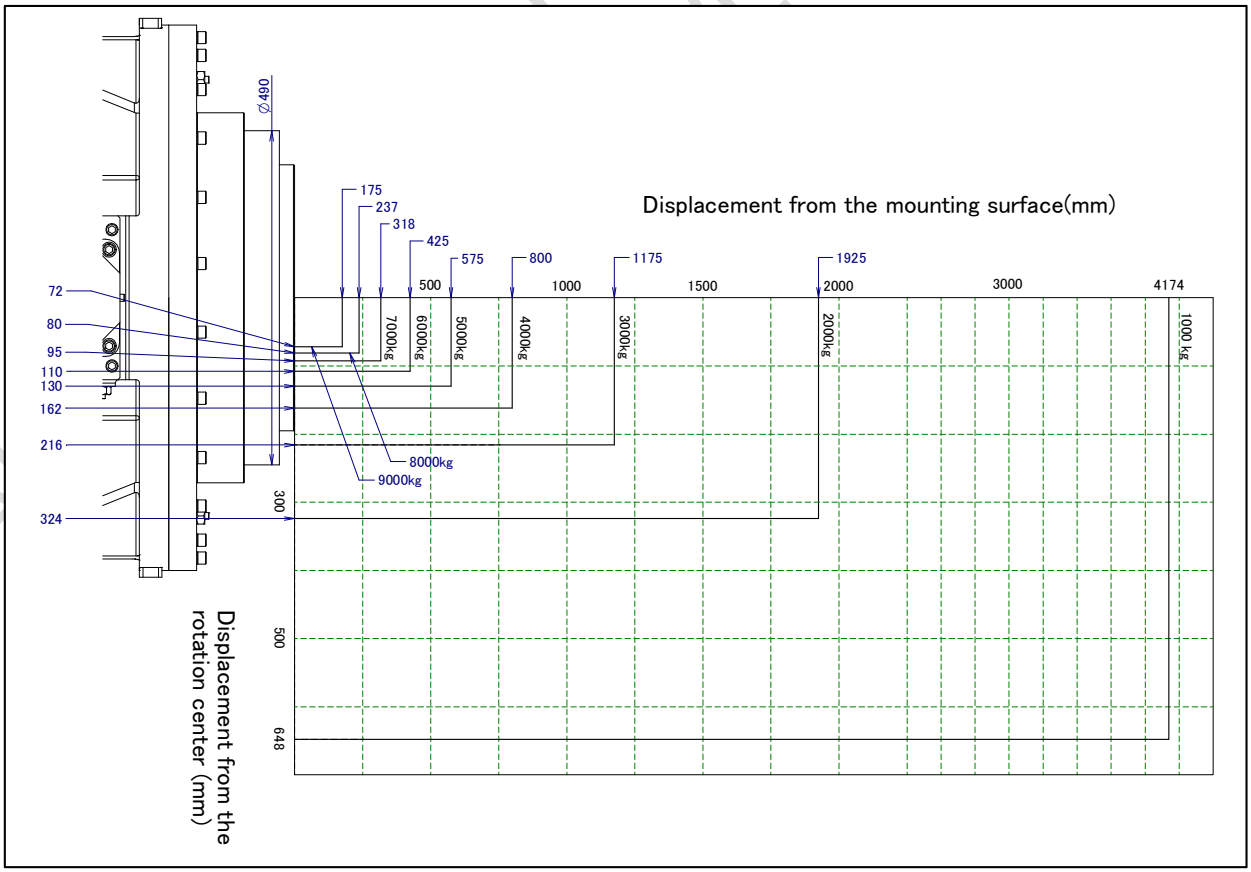


Fig. 3.4 (b) Load diagram for wall mount installation

4 EQUIPMENT INSTALLATION TO THE POSITIONER

4.1 EQUIPMENT MOUNTING FACE

As shown in Fig. 4.1 (a) tapped holes are provided to install equipment to the positioner.

⚠ CAUTION
1 Note that the use of a tapped hole not shown in the following figure is not assured. Please do not tighten both with the tightening bolts used for mechanical unit.
2 Equipment should be installed so that mechanical unit cable does not interfere. If equipment interfere, the mechanical unit cable might be disconnected, and unexpected troubles might occur.
3 Antirust oil is applied on the wrist end effector mounting surface when robot is shipped. If necessary, remove this oil.

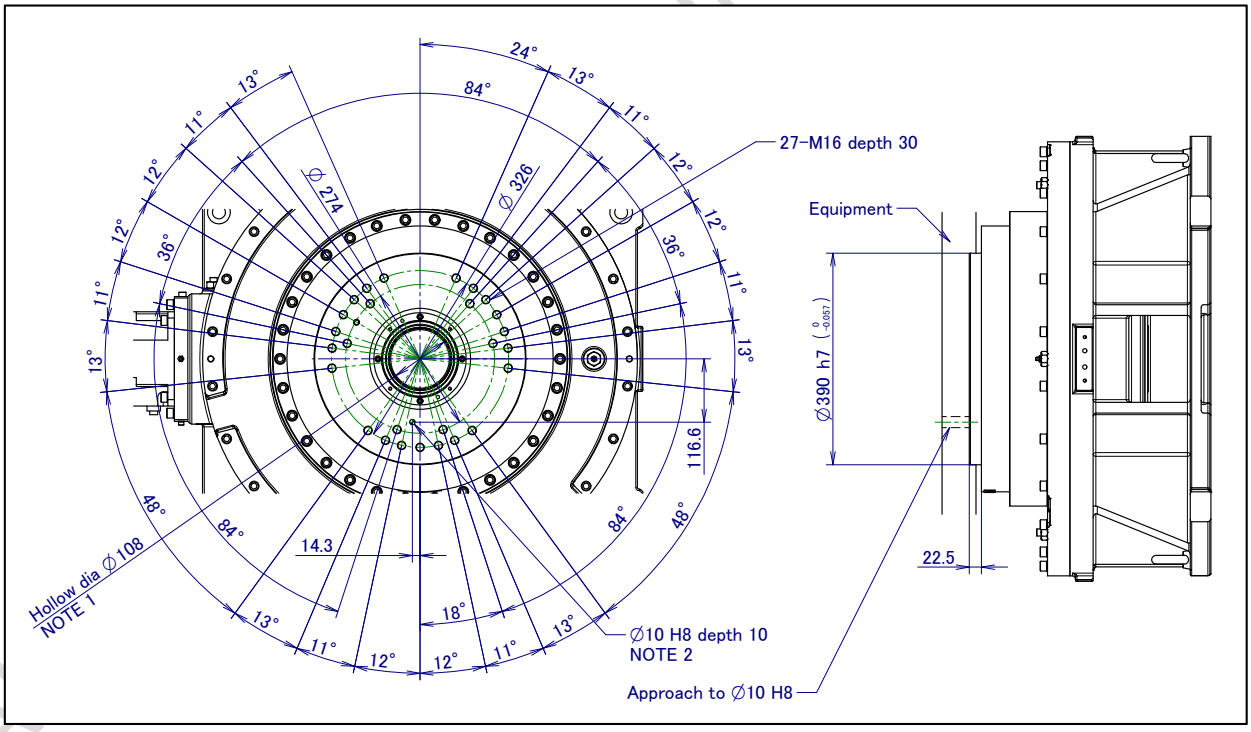


Fig. 4.1 (a) Equipment mounting faces of the positioner

NOTE
1 When using the signal line continuous rotation option, this hole cannot be used.
2 Use φ10 H8 when replacing the grease. Please leave a space around φ10 H8 for the equipment to be attached to the positioner. Please see section 7.3.2 for replacing grease.

4.2 LOAD SETTING

> ⚠ **CAUTION**
> Set the correct load condition parameter before the positioner runs. Do not operate the positioner in over when its payload is exceeded or incorrect. Do not exceed the allowable payload including connection cables and its swing. Operation in with the positioner over payload may result in troubles such as reducer life reduction.

The operation motion performance screens include the MOTION PERFORMANCE screen, MOTION PAYLOAD SET screen, and payload information and equipment information on the positioner.

1 Press the [MENU] key to display the screen menu.
2 Select [6 SYSTEM] on the next page,
3 Press the F1 ([TYPE]) key to display the screen switch menu.
4 Select "MOTION." The MOTION PERFORMANCE screen will be displayed.
5 Press F2[GROUP], then select the group 2 (positioner goroup).

```
MOTION PERFORMANCE                    JOINT 10%
    Group2
No.   PAYLOAD[kg]          Comment
 1          9000.00  [                    ]
 2          9000.00  [                    ]
 3          9000.00  [                    ]
 4          9000.00  [                    ]
 5          9000.00  [                    ]
 6          9000.00  [                    ]
 7          9000.00  [                    ]
 8          9000.00  [                    ]
 9          9000.00  [                    ]
10          9000.00  [                    ]


  Active PAYLOAD number =0
[ TYPE]  GROUP  DETAIL  ARMLOAD  SETIND >
```

6 Ten different pieces of payload information can be set using condition No.1 to No.10 on this screen. Place the cursor on one of the numbers, and press F3 (DETAIL). The MOTION PAYLOAD SET screen appears.

```
MOTION PAYLOAD SET                    JOINT 10%

    Group 2
 1 Schedule No[          1]:[Comment          ]
 2 PAYLOAD                [kg]          9000.00
 3 PAYLOAD CENTER X [cm]                 -0.19
 4 PAYLOAD CENTER Y [cm]                  14.7
 5 PAYLOAD CENTER Z [cm]                     0
 6 PAYLOAD INERTIA X [kgfcms^2]              0
 7 PAYLOAD INERTIA Y [kgfcms^2]              0
 8 PAYLOAD INERTIA Z [kgfcms^2]           3625

 [TYPE] GROUP NUMBER  DEFAULT  HELP
```

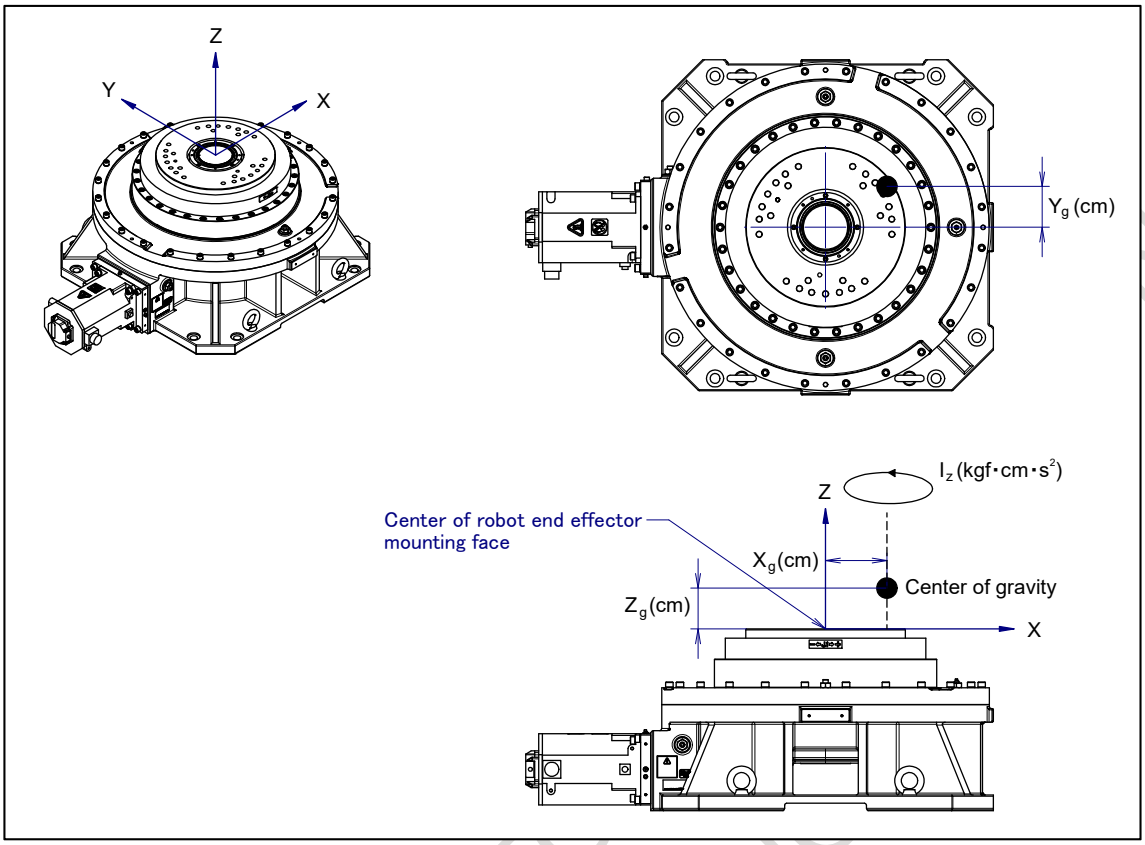


Fig. 4.2 (a) Standard tool coordinate

7 Set the payload, gravity center position, and inertia around the gravity center on the MOTION PAYLOAD SET screen. The X, Y, and Z directions displayed on this screen correspond to the respective standard tool coordinates (with no tool coordinate system set up). When values are entered, the following message appears: “Path and Cycle time will change. Set it?” Respond to the message with F4 ([YES]) or F5 ([NO]).

8 Pressing F3 ([NUMBER]) will bring you to the MOTION PAYLOAD SET screen for another condition number. For a multi group system, pressing F2 ([GROUP]) will bring you to the MOTION PAYLOAD SET screen for another group.

9 Press the [PREV] key to return to the MOTION PERFORMANCE screen. Click F5 ([SETIND]), and enter the desired payload setting condition number.

5 PIPING AND WIRING TO THE END EFFECTOR

⚠ WARNING

- When external equipment is installed in the positioner, make sure that it does not interfere with other parts of the positioner.
- Cut and discard any unnecessary length of wire strand of the end effector (hand) cable. Insulate the cable with seal tape. (See Fig. 5 (a))
- If you have equipment wiring and a process that develops static electricity, keep the end effector wiring as far away from the process as possible. If the equipment and process must remain close, be sure to insulate the cable.
- Be sure to seal the connectors of the positioner side and equipment cable and terminal parts of all cables to prevent water from entering the mechanical unit. Also, attach the cover to the unused connector.
- Frequently check that connectors are tight and cable jackets are not damaged.
- When precautions are not followed, damage to cables might occur. Cable failure may result in incorrect function of equipment, positioner faults, or damage to positioner electrical hardware. In addition, electric shock could occur when touching the power cables.

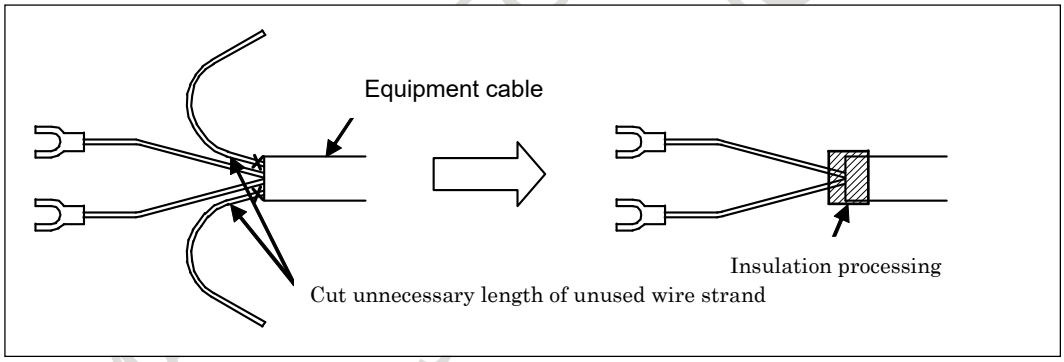


Fig. 5 (a) Treatment method of equipment cable

5.1 SIGNAL LINE CONTINUOUS ROTATION OPTION WIRING DIAGRAM

Option for continuous rotation for air supply and signal line is prepared. Use fittings according to used tubes. Continuous rotation function A05B-2600-J613 must be ordered. For the panel union, outside diameter and inside diameter of the tube, signal line, refer to the Fig. 5.1 (a) shows the air supply and signal line interface position. Fig. 5.1 (b) shows pin layout of the input side signal line and output side signal line (loose wires) specification.

Table 5.1 (a) Specification detail

Option specification	Piping/ wiring	Panel union (input side)	Positioner flange (output side)
A05B-1229-J641 Signal line continuous rotation option	Air supply	Rc3/8 x 4	One-touch pipe fitting (φ6) x 4 (Made by SMC KQ2S06-01)
	Signal	MS3102A24-28P	Loose wire 2m 0.2SQ x 24pcs

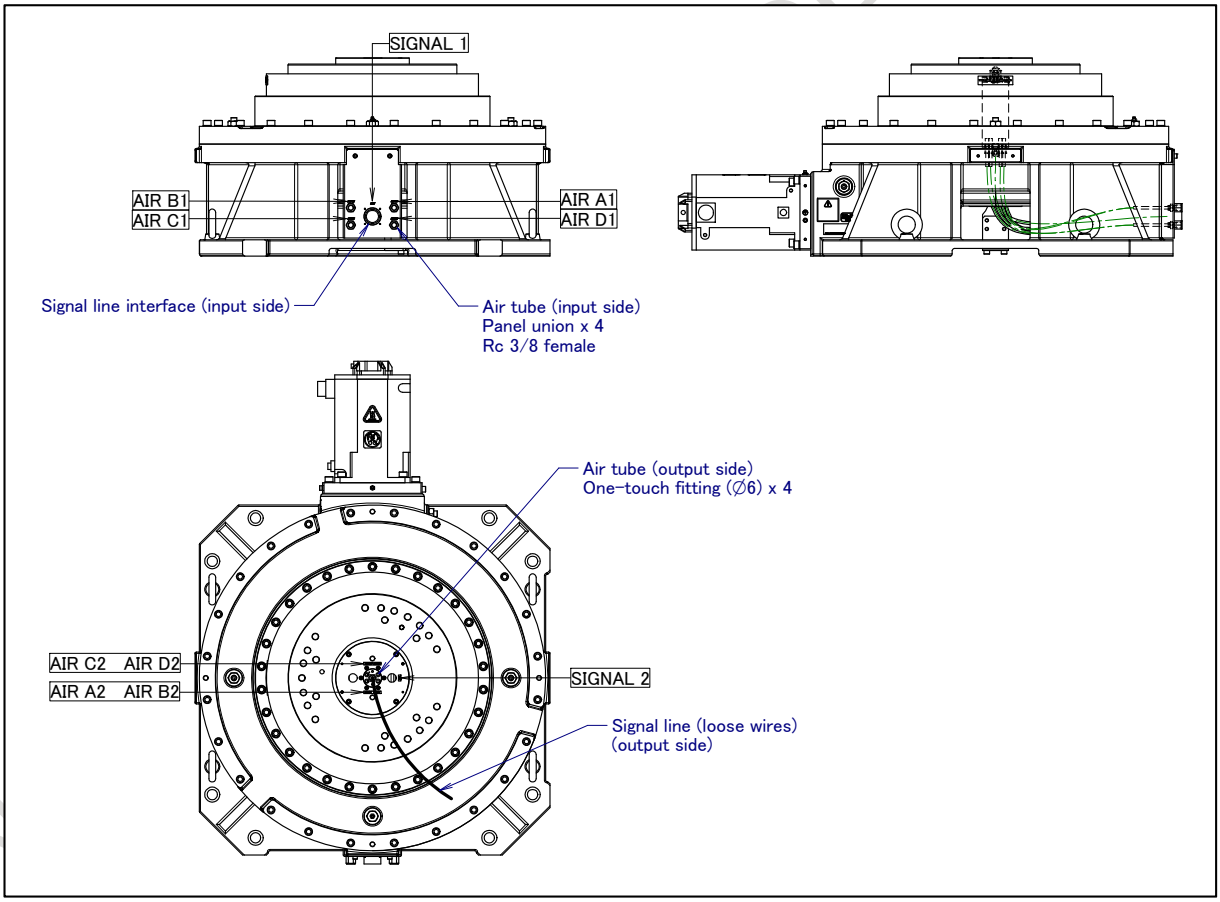


Fig. 5.1 (a) Signal line continuous rotation option wiring diagram (A05B-1229-J641)

> ⚠ **CAUTON**
> Maximum used pressure for air supply is 0.8MPa**.**
> Continuous current of signal line is 2A. Maximum voltage of the signal line is AC100/DC100V.

NOTE
Input side signal interface (Signal interface) is written “SIGNAL 1”.
Output side signal line (loose wires) is written “SIGNAL 2”.

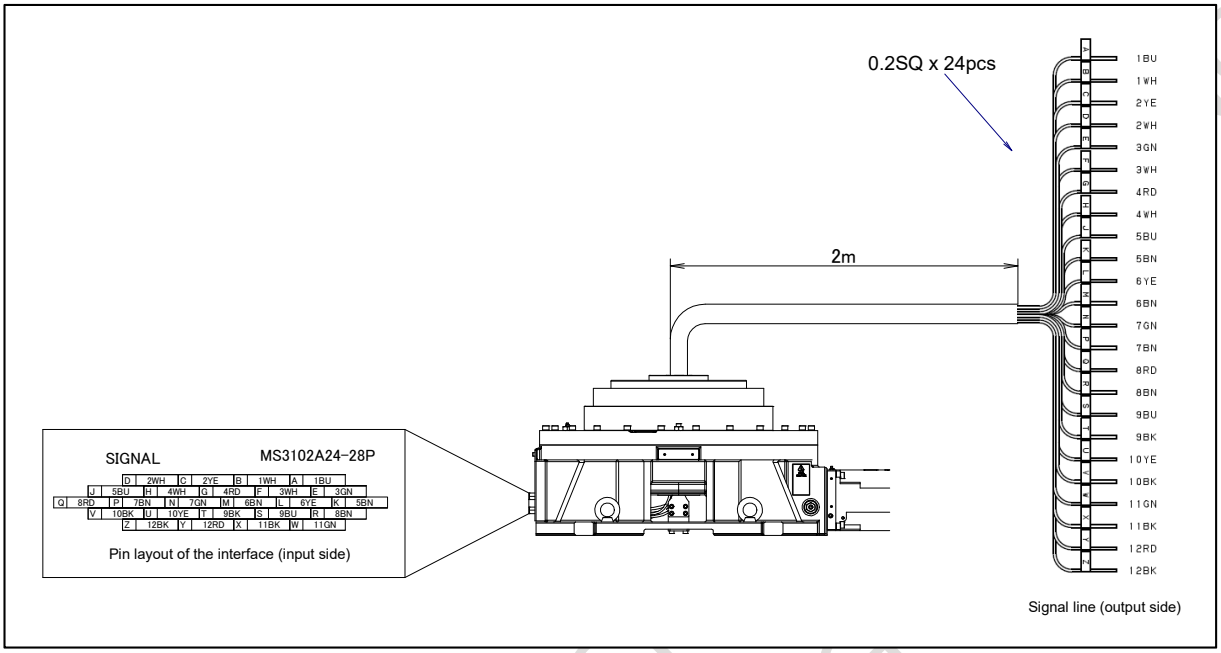


Fig. 5.1 (b) Pin layout of the SIGNAL interface (option) (A05B-1229-J641)

Table 5.1 (b) Connector specification of the SIGNAL interface (Mechanical unit side)

Cable name	Type	Maker/dealer
Signal	MS3102A24-28P	Fujikura.Ltd Japan Aviation Electronics Industry, Ltd

Table 5.1 (c) Connector specification of the SIGNAL interface (User side)

Cable name	Type	Maker/dealer
Signal	MS3106B24-28S	Fujikura.Ltd Japan Aviation Electronics Industry, Ltd

User side AS interface with loose wires is prepared as option.

Table 5.1 (d) Specification of cables with SIGNAL interface (user side)

Option specification	Length (L)	Loose wire specification
A05B-1227-K744#L7R003	7m	0.2SQ x 24pcs
A05B-1227-K744#L14R03	14m	
A05B-1227-K744#L20R03	20m	

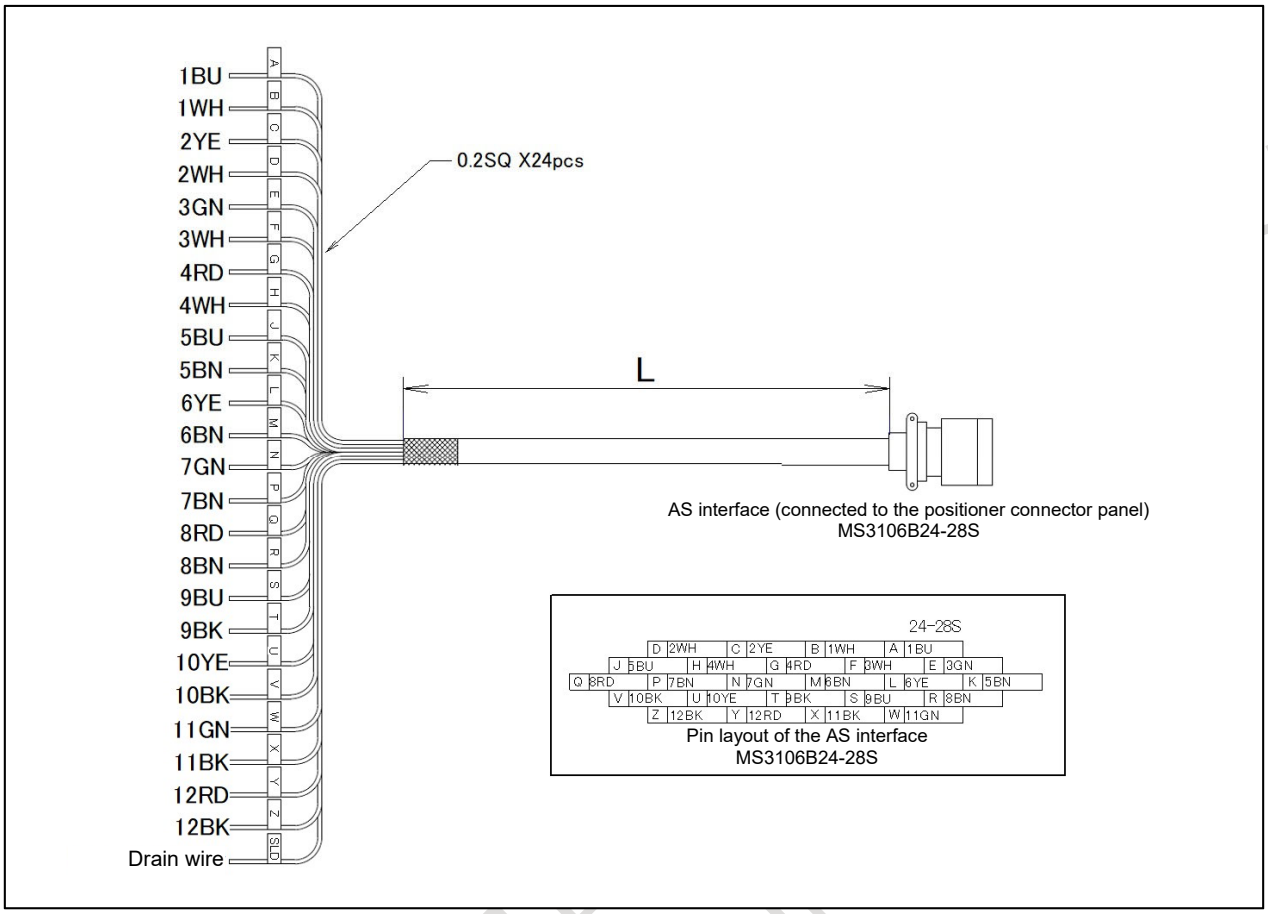


Fig. 5.1 (c) Pin layout of the user side SIGNAL interface (option)

6 AXIS LIMIT SETUP

You can change the positioner's motion range from the standard values. Changing the motion range of the positioner is effective under following circumstances:

- Used motion range of the positioner is limited.
- There's an area where tool and peripheral devices interfere with positioner.
- The length of cables and hoses attached for application is limited.

The following method used to prevent the positioner from going beyond the necessary motion range.

- Axis limit by DCS (All axes)

> ⚠ **WARNING**
> Changing the motion range of any axis affects the operating range of the positioner. To avoid trouble, carefully consider the possible effect of the change to the movable range of each axis in advance. Otherwise, it is likely that an unexpected condition will occur; for example, an alarm may occur when the positioner tries to reach a previously taught position.

6.1 CHANGE AXIS LIMIT BY DCS (OPTION)

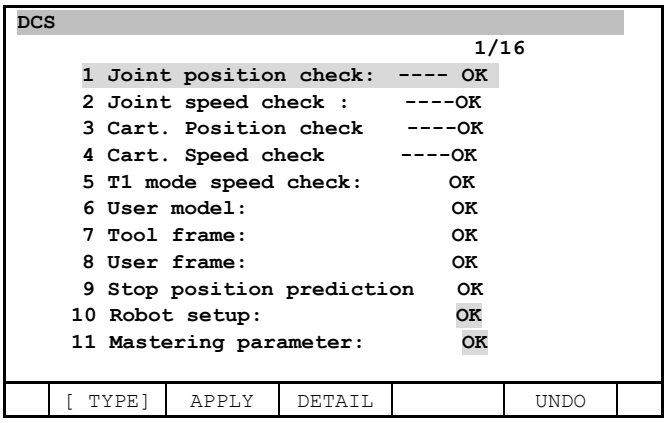
The positioner motion can be restricted with DCS (Dual check safety) function by using the following software. The positioner motion can be restricted at any angle and position if it is in positioner motion area. DCS functions are certified to meet the requirements of International Standard ISO13849-1 and IEC61508 approved by certificate authority. If only the operating space is set using Joint Position Check, the positioner stops after it goes beyond the workspace. When the motor power is shut down, the positioner's momentum causes it to move some distance before it completely stops. The actual "Positioner Stop Position" will be beyond the workspace. To stop the positioner within the positioner workspace, use the DCS Stop Position Prediction function. The stop position prediction is disabled by default.

・ DCS position/speed check function (J567)

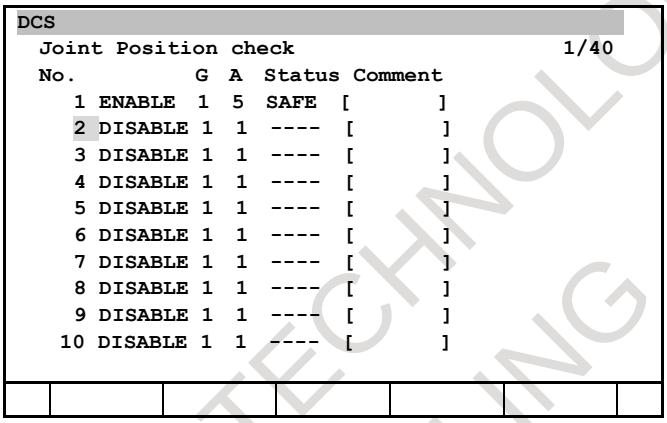
As an example, we shows the procedure to set $\pm 30^{o}$ for J1-axis in here. Refer to Controller Dual check safety function Operator's Manual (B-83184EN) for details of other setting, function and DCS stop position prediction.

Setting procedure

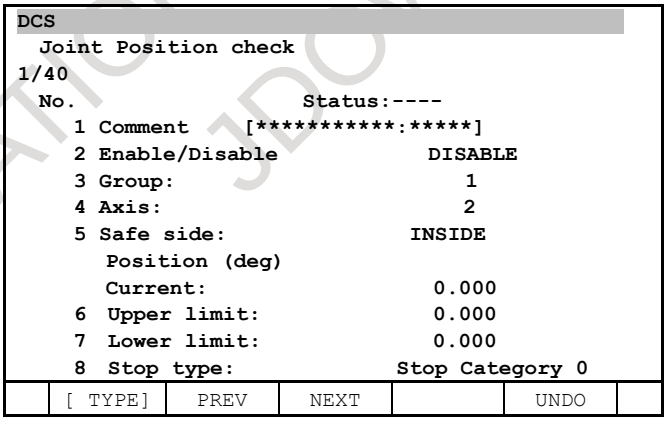
1 Press the [MENU] key to display the screen menu.
2 Press [0 NEXT] and press [6 SYSTEM].
3 Press the F1 ([TYPE]).
4 Select [DCS]. The following screen will be displayed.



5 Move the cursor to [1 Joint position check], then press the [DETAIL].

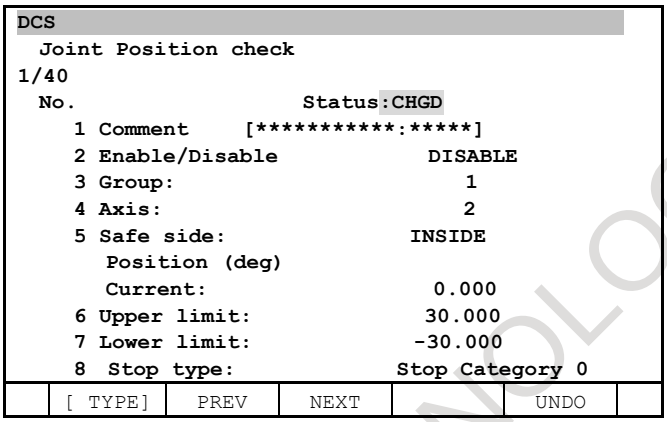


6 Move the cursor to [1], then press the [DETAIL].

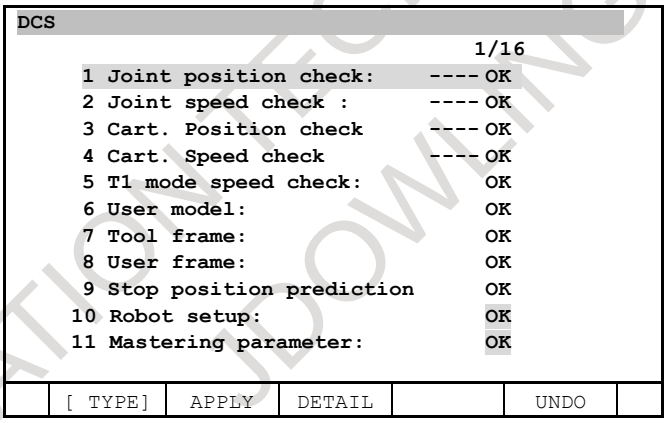


7 Move the cursor to [DISABLE], then press [CHOICE], set the status to [ENABLE].
8 Move the cursor to [Group], then input the positioner group number, then press the [ENTER] key.
9 Move the cursor to [Axis], then input “1”, then press the [ENTER] key.
10 Move the cursor to [Upper limit] right side, then input “30”, then press the [ENTER] key.
11 Move the cursor to [Lower limit] right side, then input “-30”, then press the [ENTER] key.

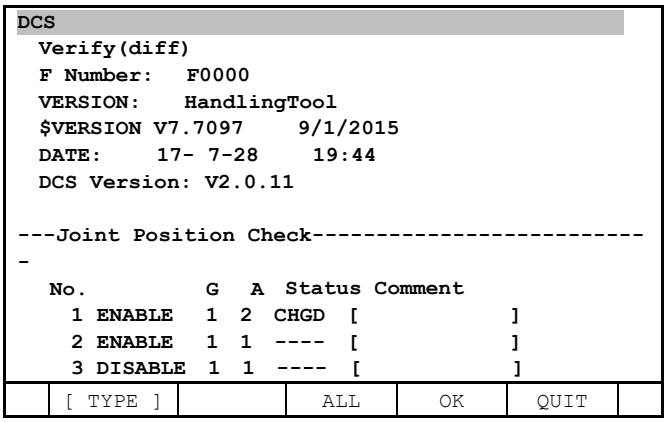
⚠ WARNING
If only the operating space is set using Joint Position Check, the positioner stops after it goes beyond the workspace. When the motor power is shut down, the positioner's momentum causes it to move some distance before it completely stops. The actual "Positioner Stop Position" will be beyond the workspace. To stop the positioner within the positioner workspace, use the DCS Stop Position Prediction function. The stop position prediction is disabled by default.



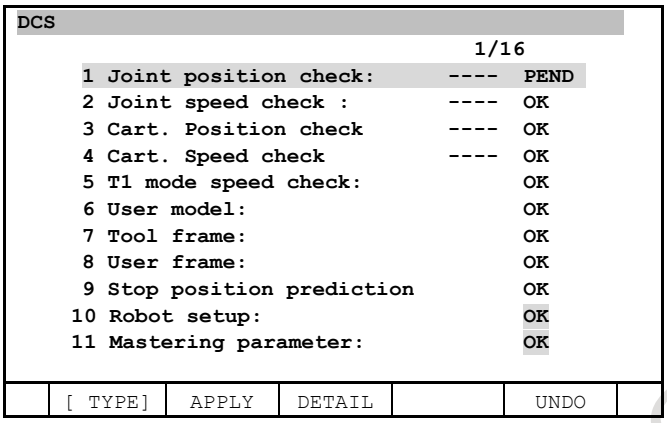
12 Press the [PREV] key two times, back to the first screen.



13 Press the [APPLY].
14 Input 4-digit password, then press the [ENTER] key. (Password default setting is "1111".)
15 The following screen will be displayed, then press the [OK].



[CHGD] on the right side of [1 Joint position check] will change to [PEND].



16 Cycle the power of the controller in the cold start mode so the new settings are enabled.

⚠ WARNING
You must cycle the power of the controller to enable the new setting. If you fail to do so, the positioner does not work normally and it may injure personnel or damage the equipment.

⚠ WARNING
1 This positioner does not have a mechanical stopper. If you need a stopper, please design it by yourself.
2 If we need to design a stopper, please contact us.

7 CHECKS AND MAINTENANCE

Optimum performance of the positioner can be maintained by performing the checks and maintenance procedures presented in this chapter. (See the APPENDIX A PERIODIC MAINTENANCE TABLE.)

NOTE

The periodic maintenance procedures described in this chapter assume that the FANUC positioner is used for up to 3840 hours a year. In cases where positioner use exceeds 3840 hours/year, adjust the given maintenance frequencies accordingly. The ratio of actual operation time/year vs. the 3840 hours/year should be used to calculate the new (higher) frequencies. For example, when using the positioner 7680 hours a year with a recommended maintenance interval of 3 years or 11520 hours, use the following calculation to determine the maintenance frequency: 3 years / 2 = perform maintenance every 1.5 years.

7.1 PERIODIC MAINTENANCE

7.1.1 Daily Checks

Clean each part, and visually check component parts for damage before daily system operation. Check the following items when necessary.

Check items	Check points and management
Oil seepage	Check to see if there is oil on the sealed part of each joint. If there is an oil seepage, clean it. **⇒"7.2.2 Confirmation of Oil Seepage"**
Air control set	(When air control set is used) **⇒"7.2.3 Confirmation of the Air Control Set"**
Vibration, abnormal noises	Check whether vibration or abnormal noises occur. When vibration or abnormal noises occur, perform measures referring to the following section: **⇒"9.1 TROUBLESHOOTING"(symptom : Vibration, Noise)**
Positioning accuracy	Check that the taught positions of the positioner have not deviated from the previously taught positions. If displacement occurs, perform the measures as described in the following section: **⇒"9.1 TROUBLESHOOTING"(symptom : Displacement)**
Peripheral equipment for proper operation	Check whether the peripheral equipment operate properly according to commands from the robot and the peripheral equipment.
Brakes for each axis	Check that the end effector drops 5 mm or less when the servo power is turned off. If the end effector (hand) drops more than the prescribed amount, perform the measures as described in the following section: **⇒"9.1 TROUBLESHOOTING"(symptom : Dropping axis)**
Warnings	Check whether unexpected warnings occur in the alarm screen on the teach pendant. If unexpected warnings occur, perform the measures as described in the following manual: **⇒"CONTROLLER OPERATOR'S MANUAL (Alarm Code List)(B-83284EN-1)"**

7.1.2 Periodic Checks and Maintenance

Check the following items at the intervals recommended below based on the period or the accumulated operating time, whichever comes first. (○ : Item needs to be performed.)

Check and maintenance intervals (Period, Accumulated operating time)						Check and maintenance item	Check points, management and maintenance method	Periodic maintenance table No.
1 month 320h	3 months 960h	1 year 3840h	1.5 years 5760h	3 years 11520h	4 years 15360h			
○ Only 1st check	○					Cleaning the controller ventilation system	Confirm the controller ventilation system is not dusty. If dust has accumulated, remove it.	9
	○					Check for external damage or peeling paint	Check whether the positioner has external damage or peeling paint due to the interference with the peripheral equipment. If an interference occurs, eliminate the cause. Also, if the external damage is serious, and causes a problem in which the positioner will not operate, replace the damaged parts.	1
	○					Check for water	Check whether the positioner is subjected to water or cutting oils. If water is found, remove the cause and wipe off the liquid.	2
	○ Only 1st check	○				Check for damages to the teach pendant cable, the operation box connection cable or the positioner connection cable	Check whether the cable connected to the teach pendant, operation box and positioner are unevenly twisted or damaged. If damage is found, replace the damaged cables.	8
	○ Only 1st check	○				Check the connection of each axis motor and other exposed connectors	Check the connection of each axis motor and other exposed connectors.	3
	○ Only 1st check	○				Retightening the external main bolts	Retighten the positioner installation bolts, bolts to be removed for inspection, and bolts exposed to the outside. Refer to the recommended bolt tightening torque guidelines at the end of the manual. An adhesive to prevent bolts from loosening is applied to some bolts. If the bolts are tightened with greater than the recommended torque, the adhesive might be removed. Therefore, follow the recommended bolt tightening torque guidelines when retightening the bolts.	4
	○ Only 1st check	○				Clean spatters, sawdust and dust	Check that spatters, sawdust, or dust does not exist on the positioner main body. If dust has accumulated, remove it.	5
			○			Replacing the mechanical unit batteries (NOTE)	Replace the mechanical unit batteries. Regardless of operating time, replace batteries at 1.5 year. **⇒"7.3.1 Replacing the Batteries"**	6
				○		Replacing the grease the reducer	Replace the grease of the reducer. **⇒"7.3.2 Replacing the Grease"**	7

Check and maintenance intervals (Period, Accumulated operating time)						Check and maintenance item	Check points, management and maintenance method	Periodic maintenance table No.
1 month 320h	3 months 960h	1 year 3840h	1.5 years 5760h	3 years 11520h	4 years 15360h			
					○	Replacing the controller batteries	Replace the controller batteries. Regardless of operating time, replace batteries at 4 years. **⇒Chapter 7 Replacing batteries of R-30*i*B/R-30*i*B Plus CONTROLLER MAINTENANCE MANUAL (B-83195EN) or R-30*i*B Mate/R-30*i*B Mate Plus CONTROLLER MAINTENANCE MANUAL (B-83525EN)"**	10

NOTE
When Connector option is ordered.

7.2 CHECK POINTS

7.2.1 Confirmation of Oil Seepage

Check items

Check there is oil on sealed part of each joint parts. If there is oil seepage, clean them.

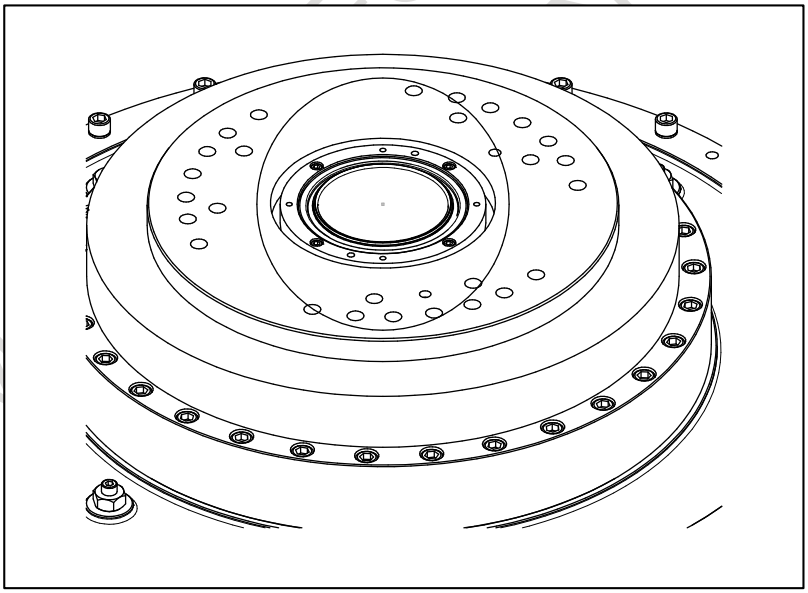


Fig. 7.2.1 (a) Check parts of oil seepage

Management

- Oil might accumulate on the outside of the seal lip depending on the movement condition or environment of the axis. If the oil changes to a state of liquid, the oil might fall depending on the axis movement. To prevent oil spots, be sure to wipe away any accumulated oil under the axis components before you operate the positioner.
- Also, drive mechanisms might become hot and the internal pressure of the grease bath might rise by frequent repetitive movement and use in high temperature environments. In these cases, normal internal pressure can be restored by venting the grease outlet. (When opening the grease outlet, refer to Subsection 7.3.2 and ensure that grease is not expelled onto the machine or tooling.)

> ⚠ **WARNING**
> Hot grease might eject suddenly when you open the grease outlet. Attach bags for collecting grease, and use appropriate protective equipment such as heat-resistant gloves, protective glasses, a face shield, or a body suit if necessary.

- If you must wipe oil frequently, and opening the grease outlet does not stop the seepage, perform the measures below.
  ⇒"9.1 TROUBLESHOOTING"(symptom : Grease leakage)

7.2.2 Confirmation of the Air Control Set (option)

When an air control set is used, check the items below.

Item	Check items	Check points
1	Air pressure	Check the air pressure using the pressure gauge on the air regulator as shown in Fig.7.2.2 (a). If it does not meet the specified pressure of 0.49 to 0.69 MPa (5-7 kgf/cm^2), adjust it using the regulator pressure-setting handle.
2	Lubricator oil mist quantity	Check the number of oil drops during operation. If it does not meet the specified value (1 drop/10-20 sec), adjust it using the lubricator control knob. Under normal usage, the lubricator will be empty in about 10 to 20 days.
3	Lubricator oil level	Check to see that the air control set oil level is within the specified level.
4	Leakage from hose	Check the joints, tubes, etc. for leaks. Retighten the joints or replace parts, as required.
5	Drain	Check the drain and release it. If the quantity of the drained liquid is significant, examine the setting of the air dryer on the air supply side.

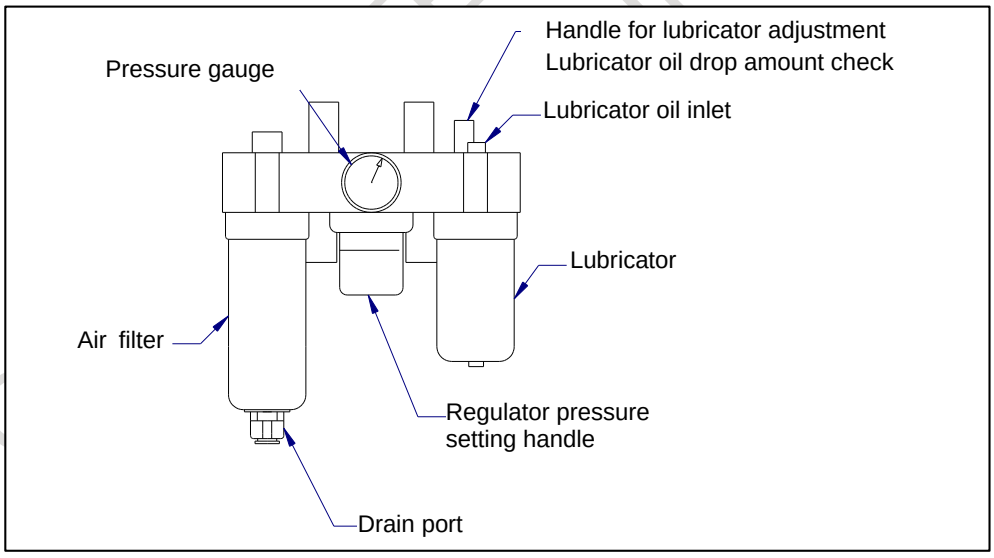


Fig. 7.2.2 (a) Air control set (option)

7.3 MAINTENANCE

7.3.1 Replacing the Batteries (1.5 year (5760 hours) checks) (for Connector option)

The position data of each axis is preserved by the backup batteries. The batteries need to be replaced every 1.5 year. Also, use the following procedure to replace when the backup battery voltage drop alarm occurs.

Procedure for replacing the battery

1 Press the EMERGENCY STOP button to prohibit the positioner motion.

> ⚠ **CAUTION**
> Be sure to keep controller power turned on. Replacing the batteries with the power turned off causes all current position data to be lost. Therefore, mastering will be required again.

2 Remove the battery case cap. (Fig. 7.3.1 (a))
3 Take out the old batteries from the battery case. At this time, the battery can be taken out by pulling the stick in the center of the battery box.
4 Insert new batteries into the battery case. Pay attention to the direction of the batteries.
5 Close the battery case cap.

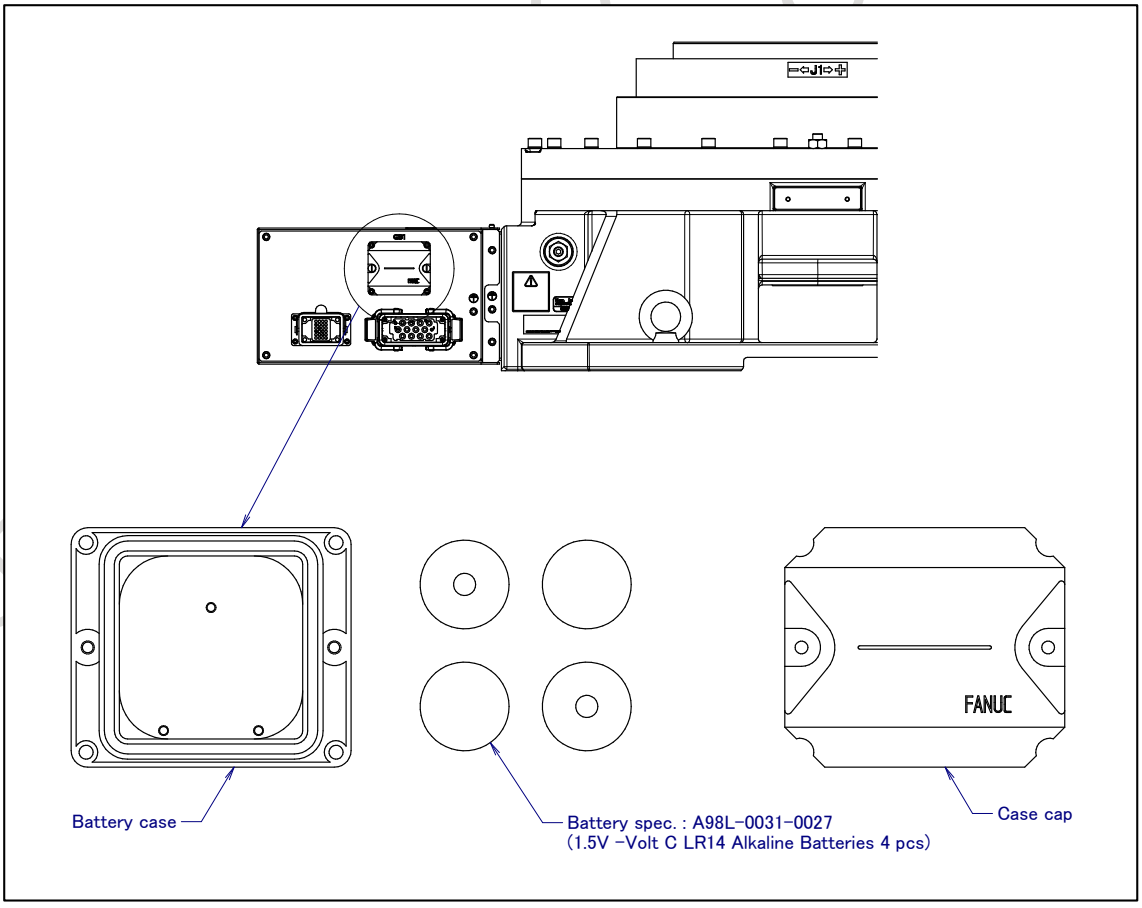


Fig. 7.3.1 (a) Replacing the battery

7.3.2 Replacing the Grease (3 years (11520 hours) checks)

According to the following procedure, replace the grease the reducer at the intervals based on every 3 years or 11520 hours, whichever comes first.

NOTE
If the robot is used under high duty, high temperature or severe environment, replacing interval might be shortened. Contact your local FANUC representative

See Table 7.3.2 (a) for the grease name and the quantity.

Table 7.3.2 (a) Grease name and amount to be replaced at regular intervals of three years (11520 hours)

Model	Specified grease	Amount of grease to be applied	Gun tip pressure	Positioner posture when greased
A05B-1229-J601	(Specification: A98L-0040-0174)	15300ml (17000g)	0.1 MPa or less (NOTE)	Arbitrary

NOTE
When a manual pump is used for greasing, the standard rate is one pumping cycles per two seconds.

⚠ WARNING
Hot grease might eject suddenly when you open the grease outlet. Attach bags for collecting grease, and use appropriate protective equipment such as heat-resistant gloves, protective glasses, a face shield, or a body suit if necessary.

1 Turn off controller power.
2 Remove the seal bolt from grease outlet 1 and 2. (Fig.7.3.2 (a))
3 Remove the taper plug from the reducer.
4 Keep greasing until the new grease pushes out the old grease and comes out from grease outlet 1 and 2.
5 Attach the seal bolts to the grease outlet1 and 2.
6 Keep greasing until the new grease pushes out the old grease and comes out from grease outlet on RV reducer.
7 Release remaining pressure using the procedure given in Subsection 7.3.3.

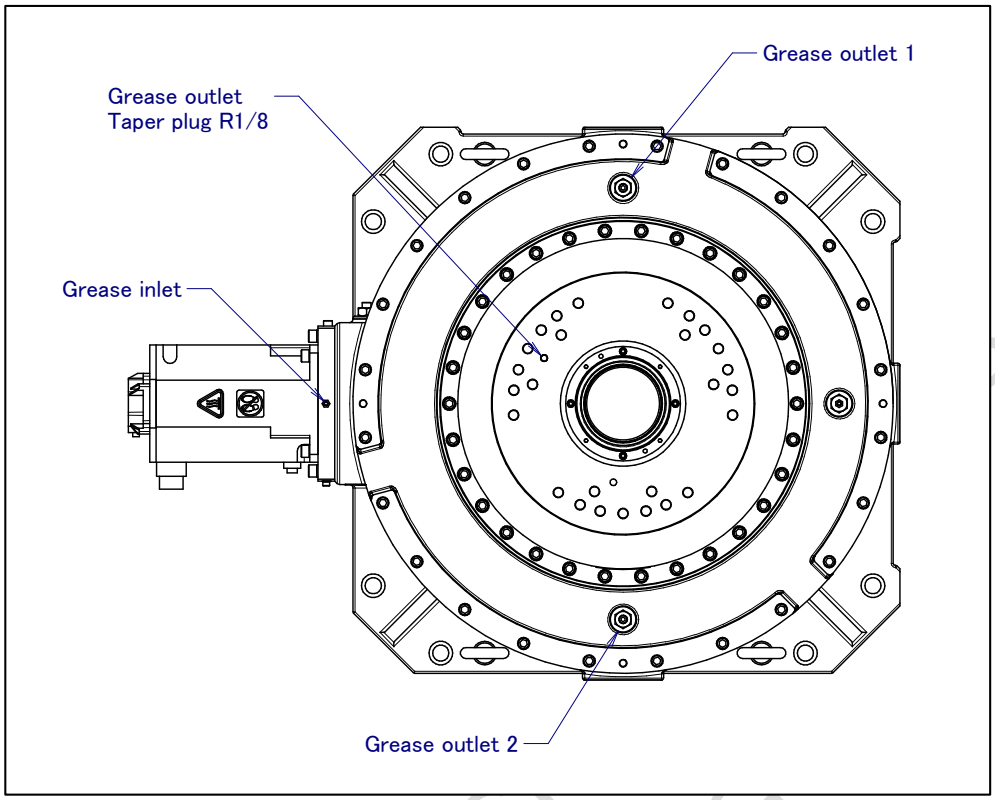


Fig. 7.3.2 (a) Greasing point of the positioner

Table 7.3.2 (b) Specification of taper plug, seal bolt, and grease nipple

Parts name	Specification
Taper plug (R1/8)	A97L-0001-0436#1-1D
Seal bolt	A97L-0218-0417#081010
Grease nipple	A97L-0218-0013#A810

⚠ CAUTION

Failure to supply grease correctly may cause an increase of the internal pressure of the grease bath. Such pressure increase will then damage the seal, which in turn leads to grease leakage and abnormal positioner operation. When performing greasing, therefore, observe the following precautions.

1 Before starting to grease, remove the seal bolt of the grease outlet to allow the grease to come out.
2 Supply grease slowly, using a manual pump. (once per two seconds)
3 Whenever possible, avoid using an air pump, which is powered by the factory air supply.
If the use of an air pump is unavoidable, supply grease with the pump at a pressure lower than or equal to the gun tip pressure (see Table 7.3.2 (a)).
4 Use grease only of the specified type. Grease of a type other than that specified may damage the reducer or lead to other problems.
5 After greasing, release remaining pressure from the grease bath using the procedure given in Subsection 7.3.3, and then close the grease outlet.
6 To prevent slipping accidents and catching fire, completely remove any excess grease from the floor or positioner.

7.3.3 Procedure for releasing remaining pressure from the grease bath

After applying grease, to release remaining pressure from the grease bath, perform a repetitive operation with a motion angle of at least 100 degrees and OVR50% for 20 minutes or more while leaving the grease outlet of reducer open.
Under the grease inlets and outlets, attach bags for collecting grease so that grease does not spatter when it comes out of the inlets or outlets.
If the above operation cannot be performed due to the environment, adjust the operating time according to the operating angle. (If only a motion angle of 50 degrees can be set, perform an operation for 40 minutes or more.) After completion of the operation, attach the plugs and seal bolts to the grease inlets and outlets. When reusing the taper plugs and seal bolts, be sure to seal them with seal tape.

7.4 STORAGE

When storing the positioner, place it on a level surface with the same posture for transportation. (See Section 1.1.)

NOTE
1 In the case of the long-term safekeeping, please fix the positioner.
2 Because a flange side is easy to get rusty, in the case of the long-term safekeeping, apply rust prevention oil to a flange side.

8 MASTERING

Mastering associates the angle of each positioner axis with the pulse count value supplied from the absolute Pulsecoder connected to the corresponding axis motor. To be specific, mastering is an operation for obtaining the pulse count value; corresponding to the zero position.

8.1 OVERVIEW

The current position of the positioner is determined according to the pulse count value supplied from the Pulsecoder on each axis.
Mastering is factory-performed. If the Connector option is ordered, it is unnecessary to perform mastering in daily operations. However, mastering is required under the following conditions:

- Motor replacement.
- Pulsecoder replacement
- Reducer replacement
- Cable replacement
- Batteries for pulse count backup in the mechanical unit have gone dead (CAUTION 2)

> **⚠ CAUTION**
> 1 Positioner data (including mastering data) and Pulsecoder data are backed up by their respective backup batteries. Data will be lost if the batteries die. Replace the batteries in the controller and mechanical units periodically. An alarm will alert you when battery voltage is low.
> 2 If the Connector option is not ordered, mastering is always required at the first startup. Please use one of the following methods for mastering.

Types of Mastering

There are following mastering methods.

Table 8.1 (a) Type of mastering

Fixture position mastering	Mastering performed with the mastering fixture before shipping.
Zero-position mastering (witness mark mastering)	Mastering which performed with all axes set at the 0-degree position. A zero-position mark (witness mark) is attached to each positioner axis. This mastering is performed with all axes aligned to their respective witness marks.
Quick mastering	This is performed at a user-specified position. The corresponding count value is obtained from the rotation count of the Pulsecoder connected to the relevant motor and the rotation angle within one rotation. Quick mastering uses the fact that the absolute value of a rotation angle within one rotation will not be lost. (All axes at the same time)
Quick mastering for single axis	This is performed at a user-specified position for one axis. The corresponding count value is obtained from the rotation count of the Pulsecoder connected to the relevant motor and the rotation angle within one rotation. Quick mastering uses the fact that the absolute value of a rotation angle within one rotation will not be lost.
Single axis mastering	Mastering which performed for one axis at a time. The mastering position for each axis can be specified by the user. Useful in performing mastering on a specific axis.
Mastering data entry	Enter the Mastering data directly.

This section describes zero-position mastering, quick mastering, quick mastering for single axis, single-axis mastering, and mastering data entry. For more detailed mastering (fixture position mastering), contact your local FANUC representative.

This section describes zero-position mastering, quick mastering, single-axis mastering, and mastering data entry. For more detailed mastering (fixture position mastering), contact your local FANUC representative.

> **⚠ CAUTION**
> 1 If mastering is performed incorrectly, the positioner may behave unexpectedly. This is very dangerous. For this reason, the Master/Cal screen is designed to appear only when the $MASTER_ENB system variable is 1 or 2. After performing positioning, press F5, ([DONE]) on the Master/Cal screen. The $MASTER_ENB system variable is then reset to 0 automatically, and the Master/Cal screen will disappear.
> 2 Before performing mastering, it is recommended that you back up the current mastering data.

8.2 RESETTING ALARMS AND PREPARING FOR MASTERING

Before performing mastering because a motor is replaced, you must release the relevant alarm and display the positioning menu.

Alarm displayed

"SRVO-062 BZAL" or "SRVO-075 Pulse not established"

Procedure

1 Display the positioning menu by following steps 1 to 6.
   1 Press the [MENU] key to display the screen menu.
   2 Press [0 NEXT] and select [6 SYSTEM].
   3 Press F1 [TYPE], and select [SYSTEM Variable] from the menu.
   4 Place the cursor on $MASTER_ENB, then key in [1] and press [ENTER] key.
   5 Press F1 [TYPE], and select[Master/Cal] from the menu.
   6 Select the desired mastering type from the [Master/Cal] menu.

2 To reset the "SRVO-062 BZAL" alarm, follow steps 1 to 5.
   1 Press the [MENU] key to display the screen menu.
   2 Press [0 NEXT] and select [6 SYSTEM].
   3 Press F1 [TYPE], and select [Master/Cal] from the menu.
   4 Press the F3 [RES_PCA], then press F4 [YES].
   5 Turn off the controller power and on again.

3 To reset the "SRVO-075 Pulse not established " alarm, follow steps 1 to 2.
   1 When the controller power is turned on again, the message "SRVO-075 Pulse not established" appears again.
   2 Move the axis for which the message mentioned above has appeared in either direction till the alarm disappears when you press [FAULT RESET].

8.3 ZERO POSITION MASTERING

Zero-position mastering (witness mark mastering) is performed with all axes set at the 0-degree position. A zero-position mark (witness mark) is attached to each positioner axis (Fig. 8.3 (a)). This mastering is performed with all axes set at the 0-degree position using their respective witness marks.

Zero-position mastering involves a visual check. It cannot be so accurate. It should be used only as a quick-fix method.

Procedure of Zero-position Mastering

1 Press the “GROUP” button on the lower right of the teach pendant, change to GROUP 2 (G2).
2 Press the [MENU] key to display the screen menu.
3 Select [0 NEXT] and press [6 SYSTEM].
4 Press F1 [TYPE].
5 Select [Master/Cal].

```
SYSTEM Master/Cal          AUTO   JOINT 10 %
                                  TORQUE = [ON ]
 1 FIXTURE POSITION MASTER
 2 ZERO POSITION MASTER
 3 QUICK MASTER
 4 QUICK MASTER FOR SINGLE AXIS
 5 SINGLE AXIS MASTER
 6 SET QUICK MASTER REF
 7 CALIBRATE
     Press 'ENTER' or number key to select.

 [ TYPE ]   LOAD   RES_PCA                DONE
```

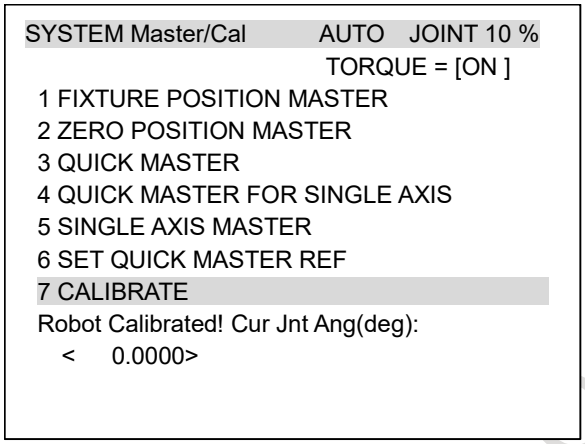
6 Jog the positioner into a posture for mastering.

NOTE
Brake control can be released by setting the system variables as follows:
$PARAM_GROUP.SV_OFF_ALL : FALSE
$PARAM_GROUP.SV_OFF_ENB[*] : FALSE (for all axes)
After changing the system variables, cycle power of the controller.

7 Select [2 Zero Position Master]. Press F4 [YES].

```
SYSTEM Master/Cal          AUTO   JOINT 10 %
                                  TORQUE = [ON ]
 1 FIXTURE POSITION MASTER
 2 ZERO POSITION MASTER
 3 QUICK MASTER
 4 QUICK MASTER FOR SINGLE AXIS
 5 SINGLE AXIS MASTER
 6 SET QUICK MASTER REF
 7 CALIBRATE
 Robot Mastered! Mastering Data:
    <0>

 [ TYPE ]   LOAD   RES_PCA                DONE
```

8 Select [7 CALIBRATE] and press F4 [YES]. Mastering will be performed automatically. Alternatively, turn off the controller power and on again. Turning on the power always causes positioning to be performed.



9 After positioning is completed, press F5 [DONE].

10 Return brake control to original setting, and cycle power of the controller.

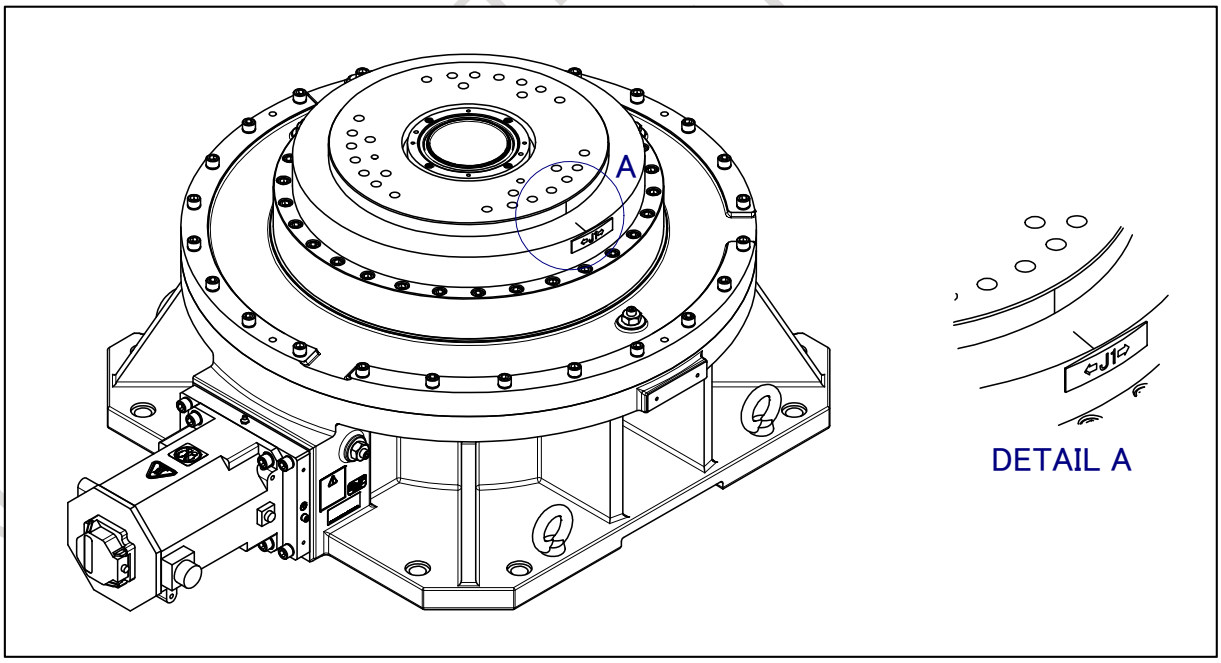


Fig. 8.3 (a) Zero-position mark (witness mark) of the positioner

8.4 QUICK MASTERING

Quick mastering is performed at a user-specified position. The pulse count value is obtained from the rotation speed of the Pulsecoder connected to the relevant motor and the rotation angle within one rotation. Quick mastering uses the fact that the absolute value of a rotation angle within one rotation will not be lost.

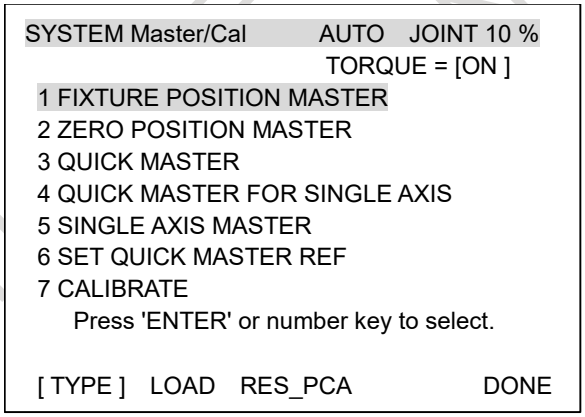
Quick mastering is factory-performed at 0°. Do not change the setting unless there is any problem.

If setting the positioner at the position mentioned above is impossible, you must re-set the quick mastering reference position using the following method. (It would be convenient to set up a marker that can work in place of the witness mark.)

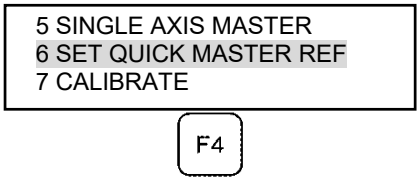
⚠ CAUTION
1 Quick mastering can be used, if the pulse count value is lost, for example, because a low voltage has been detected on the backup battery for the pulse counter.
2 Quick mastering cannot be used, after the Pulsecoder is replaced or after the mastering data is lost from the robot controller.

Procedure Recording the Quick Mastering Reference Position

1 Press the “GROUP” button on the lower right of the teach pendant, change to GROUP 2 (G2).
2 Select SYSTEM.
3 Select Master/Cal. Master/Cal screen will be displayed.



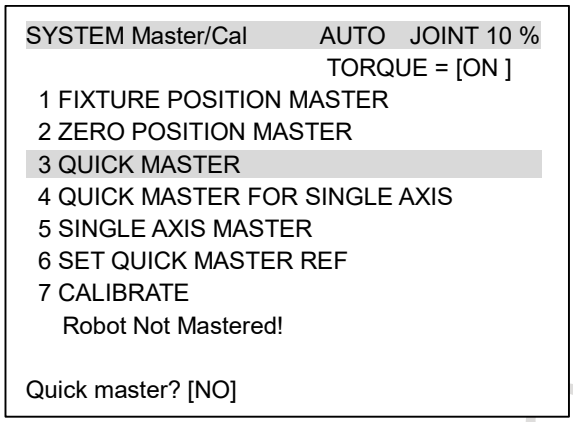
4 Jog the positioner to the quick mastering reference position.
5 Select [6 SET QUICK MASTER REF] and press F4 [YES]. Quick mastering reference position will be set.



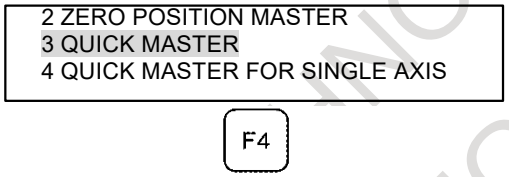
⚠ CAUTION
If the positioner has lost mastering data due to mechanical disassembly or repair, you cannot perform this procedure. In this case, perform Fixture position mastering or zero –position mastering is required to restore mastering data.

Procedure of Quick Mastering

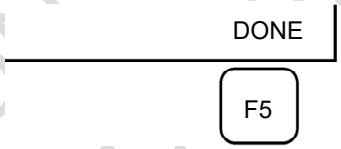
1 Press the “GROUP” button on the lower right of the teach pendant, change to GROUP 2 (G2).
2 Display the Master/Cal screen.



3 Jog the positioner to the quick mastering reference position.
4 Select [3 QUICK MASTER] and press F4 [YES]. Quick mastering reference position will be set.



5 Select [7 CALIBRATE] and press [ENTER] key. Calibration is executed. Calibration is executed by cycling power.
6 After completing the calibration, press F5 [Done].



7 Return brake control to original setting, and cycle power of the controller.

8.5 QUICK MASTERING FOR SINGLE AXIS

Quick mastering for single axis is performed at a user-specified position for one axis. The pulse count value is obtained from the rotation times of the Pulsecoder connected to the relevant motor and the rotation angle within one rotation. Quick mastering uses the character that the absolute value of a rotation angle within one rotation will not be lost.

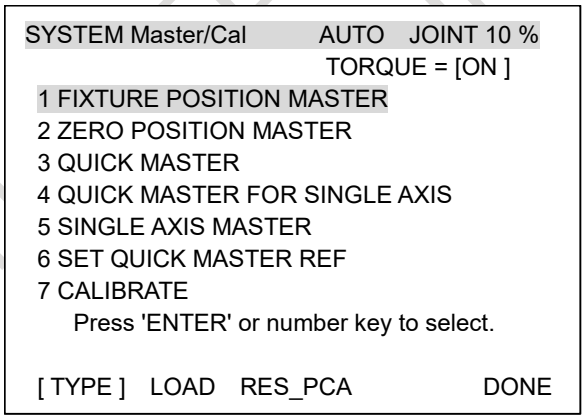
Quick mastering is factory-performed at 0°. Do not change the setting unless there is any problem.

If setting the positioner at the position mentioned above is impossible, you must re-set the quick mastering reference position using the following method. (It would be convenient to set up a marker that can work in place of the witness mark.)

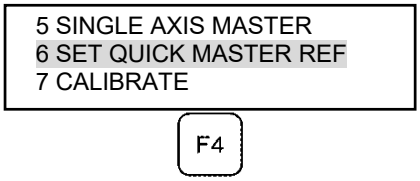
> ⚠ **CAUTION**
> 1 Quick mastering can be used, if the pulse count value is lost, for example, because a low voltage has been detected on the backup battery for the pulse counter.
> 2 Quick mastering cannot be used, after the Pulsecoder is replaced or after the mastering data is lost from the robot controller.

Procedure Recording the Quick Mastering Reference Position

1 Press the “GROUP” button on the lower right of the teach pendant, change to GROUP 2 (G2).
2 Select [6 SYSTEM].
3 Select [Master/Cal]. The positioning screen will be displayed.



4 Jog the positioner to the quick mastering reference position.
5 Select [6 SET QUICK MASTER REF] and press F4 [YES]. Quick mastering reference position will be set.



> ⚠ **CAUTION**
> If the positioner has lost mastering data due to mechanical disassembly or repair, you cannot perform this procedure. In this case, perform Fixture position mastering or zero –position mastering is required to restore mastering data.

Procedure of Quick Mastering for single axis

1 Press the “GROUP” button on the lower right of the teach pendant, change to GROUP 2 (G2).
2 Display the Master/Cal screen.

```
SYSTEM Master/Cal          AUTO   JOINT 10 %
                                  TORQUE = [ON ]
 1 FIXTURE POSITION MASTER
 2 ZERO POSITION MASTER
 3 QUICK MASTER
 4 QUICK MASTER FOR SINGLE AXIS
 5 SINGLE AXIS MASTER
 6 SET QUICK MASTER REF
 7 CALIBRATE
    Press 'ENTER' or number key to select.

 [ TYPE ]   LOAD   RES_PCA              DONE
```

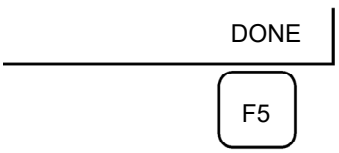
3 Select [4 QUICK MASTER FOR SINGLE AXIS]. quick master for single axis screen will be displayed.

```
SINGLE AXIS MASTER                AUTO    JOINT 10%
                                                1/9
    ACTUAL   POS     (MSTR POS)      (SEL)    [ST]
J1          0.000    (     0.000)    (0)      [2]
J2          0.000    (     0.000)    (0)      [2]
J3          0.000    (     0.000)    (0)      [2]
J4          0.000    (     0.000)    (0)      [2]
J5          0.000    (     0.000)    (0)      [2]
J6          0.000    (     0.000)    (0)      [0]
E1          0.000    (     0.000)    (0)      [0]
E2          0.000    (     0.000)    (0)      [0]
E3          0.000    (     0.000)    (0)      [0]

                                                EXEC
```

4 Move the cursor to the [SEL] column for the unmastered axis and press the numeric key [1]. Setting of [SEL] is available for one or more axes.

```
SINGLE AXIS MASTER                AUTO    JOINT 10%
                                                1/9
    ACTUAL   POS     (MSTR POS)      (SEL)    [ST]
J5          0.000    (     0.000)    (1)      [2]
J6          0.000    (     0.000)    (1)      [2]

                                                EXEC
```

5 Turn off brake control, then jog the positioner to the quick mastering reference position.
6 Press F5 [EXEC]. Mastering is performed. So, [SEL] is reset to 0, and [ST] is re-set to 2.
7 Select [7 CALIBRATE] and press [ENTER] key. Calibration is executed. Calibration is executed by cycling power.
8 After completing the calibration, press F5 Done.



9 Return brake control to original setting, and cycle power of the controller.

8.6 SINGLE AXIS MASTERING

Single axis mastering is performed for one axis at a time. The mastering position for each axis can be specified by the user. Single axis mastering can be used, if mastering data for a specific axis is lost, for example, because a low voltage has been detected on the pulse counter backup battery or because the Pulsecoder has been replaced. The 1-axis positioner is J1-axis of the group 2.

```
SINGLE AXIS MASTER              AUTO    JOINT 10%
                                                1/9
    ACTUAL   POS    (MSTR POS)      (SEL)   [ST]
J1          0.000   (       0.000)  (0)     [2]
J2          0.000   (       0.000)  (0)     [2]
J3          0.000   (       0.000)  (0)     [2]
J4          0.000   (       0.000)  (0)     [2]
J5          0.000   (       0.000)  (0)     [2]
J6          0.000   (       0.000)  (0)     [0]
E1          0.000   (       0.000)  (0)     [0]
E2          0.000   (       0.000)  (0)     [0]
E3          0.000   (       0.000)  (0)     [0]

                                                EXEC
```

Table 8.6 (a) Items set in single axis mastering

Item	Description
Current position (ACTUAL AXIS)	The current position of the positioner is displayed for each axis in degree units.
Mastering position (MSTR POS)	A mastering position is specified for an axis to be subjected to single axis mastering. It would be convenient if it is set to the 0 degree position.
SEL	This item is set to 1 for an axis to be subjected to single axis mastering. Usually, it is 0.
ST	This item indicates whether single axis mastering has been completed for the corresponding axis. It cannot be changed directly by the user. The value of the item is reflected in $EACHMST_DON (1 to 9). 0 :Mastering data has been lost. Single axis mastering is necessary. 1 :Mastering data has been lost. (Mastering has been performed only for the other interactive axes.) Single axis mastering is necessary. 2 :Mastering has been completed.

Procedure of Single axis mastering

1 Press the “GROUP” button on the lower right of the teach pendant, change to GROUP 2 (G2).
2 Select [6 SYSTEM].
3 Select [Master/Cal].

```
SYSTEM Master/Cal          AUTO   JOINT 10 %
                                  TORQUE = [ON ]
 1 FIXTURE POSITION MASTER
 2 ZERO POSITION MASTER
 3 QUICK MASTER
 4 QUICK MASTER FOR SINGLE AXIS
 5 SINGLE AXIS MASTER
 6 SET QUICK MASTER REF
 7 CALIBRATE
     Press 'ENTER' or number key to select.

 [ TYPE ]   LOAD   RES_PCA                DONE
```

4 Select [5 SINGLE AXIS MASTER]. The following screen will be displayed.

```
SINGLE AXIS MASTER          AUTO    JOINT 10%
                                          1/9
   ACTUAL   POS   (MSTR POS)    (SEL)   [ST]
J1          0.000 (     0.000)  (0)     [2]
J2          0.000 (     0.000)  (0)     [2]
J3          0.000 (     0.000)  (0)     [2]
J4          0.000 (     0.000)  (0)     [2]
J5          0.000 (     0.000)  (0)     [2]
J6          0.000 (     0.000)  (0)     [0]
E1          0.000 (     0.000)  (0)     [0]
E2          0.000 (     0.000)  (0)     [0]
E3          0.000 (     0.000)  (0)     [0]

                                        EXEC
```

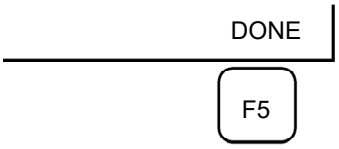
5 For the axis to which to perform single axis mastering, set (SEL) to "1." Setting of [SEL] is available for one or more axes.
6 Turn off brake control, then jog the positioner to the mastering position.
7 Enter axis data for the mastering position.
8 Press F5 [EXEC]. Mastering is performed. So, [SEL] is reset to 0, and [ST] is re-set to 2 or 1.

```
SINGLE AXIS MASTER          AUTO    JOINT 10%
                                          6/9
   ACTUAL   POS   (MSTR POS)    (SEL)   [ST]
J1          0.000 (     0.000)  (0)     [2]
J2          0.000 (     0.000)  (0)     [2]
J3          0.000 (     0.000)  (0)     [2]
J4          0.000 (     0.000)  (0)     [2]
J5          0.000 (     0.000)  (0)     [2]
J6         90.000 (     0.000)  (1)     [0]
E1          0.000 (     0.000)  (0)     [0]
E2          0.000 (     0.000)  (0)     [0]
E3          0.000 (     0.000)  (0)     [0]

                                        EXEC
```

9 When single axis mastering is completed, press the [PREV] key to resume the previous screen.

```
SYSTEM Master/Cal          AUTO   JOINT 10 %
                                  TORQUE = [ON ]
 1 FIXTURE POSITION MASTER
 2 ZERO POSITION MASTER
 3 QUICK MASTER
 4 QUICK MASTER FOR SINGLE AXIS
 5 SINGLE AXIS MASTER
 6 SET QUICK MASTER REF
 7 CALIBRATE
     Press 'ENTER' or number key to select.

 [ TYPE ]   LOAD   RES_PCA              DONE
```

10 Select [7 CALIBRATE], then press F4 [YES]. Positioning is performed. Alternatively, turn off the controller power and on again. Positioning is performed.
11 After positioning is completed, press F5 [DONE].



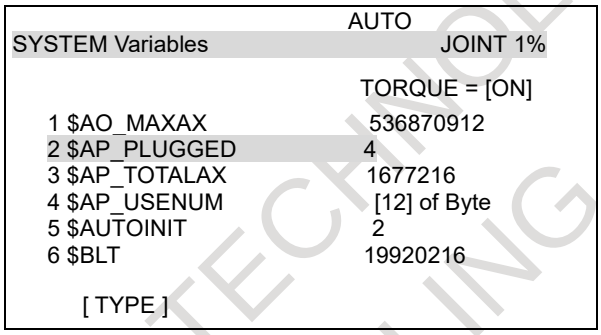
12 Return brake control to original setting, and cycle power of the controller.

8.7 MASTERING DATA ENTRY

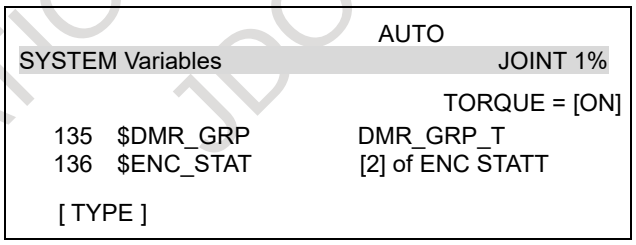
This function enables mastering data values to be assigned directly to a system variable. It can be used if mastering data has been lost but the pulse count is preserved.

Mastering data entry method

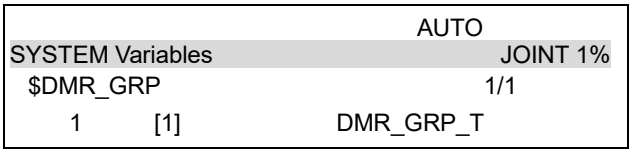
1 Press the “GROUP” button on the lower right of the teach pendant, change to GROUP 2 (G2).
2 Press the [MENU] key, then press [0 NEXT] and select [6 SYSTEM].
3 Press F1 [TYPE]. Select [Variables]. The system variable screen appears.

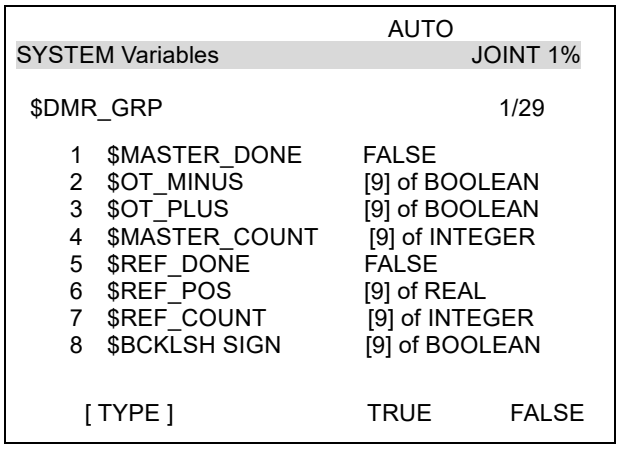


4 Change the mastering data.
The mastering data is saved to the $DMR_GRP.$MASTER_COUN system variable.

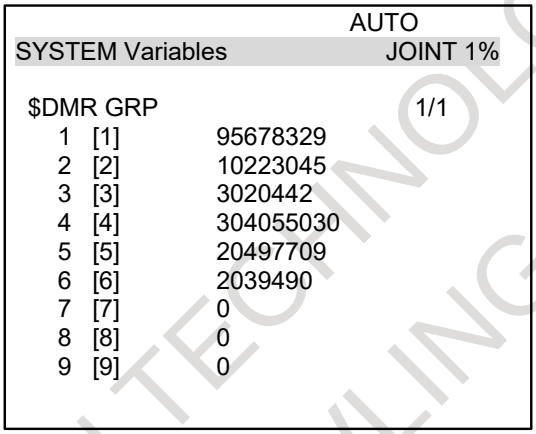


5 Select $DMR_GRP.

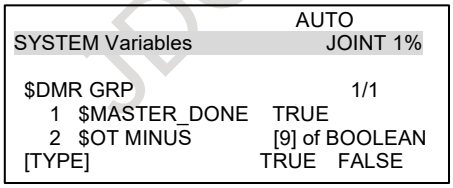




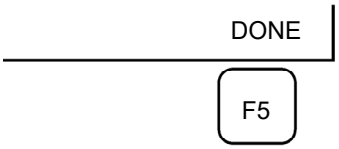
6 Select $MASTER_COUN, and enter the mastering data you have recorded.



7 Press the [PREV] key.
8 Set $MASTER_DONE to TRUE.



9 Display the positioning screen, and select [7 CALIBRATE], then press F4 [YES].
10 After completing positioning, press F5 [DONE].



8.8 VERIFYING MASTERING

1 How to verify that the positioner is mastered properly:
Usually, positioning is performed automatically when the power is turned on. To check whether mastering has been performed correctly, examine if the current displayed position meets the actual positioner position by using the procedure described below:
(1) Reproduce a particular point in a program. Check whether the point agrees with the specified position.
(2) Set all axes of the positioner to their 0-degree (0 rad) positions. Check that the zero-degree position marks indicated in Section 8.3 of OPERATOR'S MANUAL are aligned. There is no need to use a visual aid.

If the displayed and actual positions do not match, the counter value for a Pulsecoder may have been invalidated as a result of an alarm described in 2. Alternatively, the mastering data in system variable $DMR_GRP.$MASTER_COUN may have been overwritten as a result of an operation error or some other reason.
Compare the data with the values indicated on the supplied data sheet. This system variable is overwritten whenever mastering is performed. Whenever mastering is performed, record the value of the system variable on the data sheet.

2 Alarm type displayed during mastering and their solution method:
(1) BZAL alarm
This alarm is displayed if the Pulsecoder's backup battery voltage decreases to 0 V while the power to the controller is disconnected. Furthermore, if the Pulsecoder connector is removed for cable replacement, etc. this alarm is displayed as the voltage decreases to 0. Confirm if the alarm will disappear by performing a pulse reset (See Section 8.2.). Then, cycle power of the controller to check if the alarm disappears or not.
The battery may be drained if the alarm is still displayed. Perform a pulse reset, and turn off and on the controller power after replacing the battery. Note that, if this alarm is displayed, all the original data held by the Pulsecoder will be lost. Mastering is required.
(2) BLAL alarm
This alarm is displayed if the voltage of the Pulsecoder's backup battery has fallen to a level where backup is no longer possible. If this alarm is displayed, replace the battery with a new one immediately while keeping the power turned on. Check whether the current position data is valid, using the procedure described in 1.
(3) Alarm notification like CKAL, RCAL, PHAL, CSAL, DTERR, CRCERR, STBERR, and SPHAL may have trouble with Pulsecoder, contact your local FANUC representative.

9 TROUBLESHOOTING

The source of mechanical unit problems may be difficult to locate because of overlapping causes. Problems may become further complicated, if they are not corrected properly. Therefore, you must keep an accurate record of problems and to take proper corrective actions.

9.1 TROUBLESHOOTING

Table 9.1 (a) shows the major troubleshooting symptoms that may occur in the mechanical unit and their probable causes. If you cannot pinpoint a failure cause or which measures to take, contact your local FANUC representative.

Table 9.1 (a) Troubleshooting

Symptom	Description	Cause	Measure
Vibration Noise	- The J1 base lifts off the floor plate as the positioner operates. - There is a gap between the J1 base and floor plate. - A J1 base retaining bolt is loose.	[J1 base fastening] - It is likely that the positioner J1 base is not securely fastened to the floor plate. - Probable cause is a loose bolt, an insufficient degree of surface flatness, or foreign material caught between the J1 base and floor plate. - If the positioner is not securely fastened to the floor plate, the J1 base lifts the floor plate as the positioner operates, allowing the base and floor plates to strike each other, which, in turn, leads to vibration.	- If a bolt is loose, apply LOCTITE and tighten it to the appropriate torque. - Adjust the floor plate surface flatness to within the specified tolerance. - If there is any foreign material between the J1 base and floor plate, remove it.
	- The rack or floor plate vibrates during operation of the positioner.	[Rack or floor] - It is likely that the rack or floor is not sufficiently rigid. - If the rack or floor is not sufficiently rigid, reaction from the positioner deforms the rack or floor, leading to vibration.	- Reinforce the rack or floor to make it more rigid. - If it is impossible to reinforce the rack or floor, modify the positioner control program; doing so might reduce the amount of vibration.
	- Vibration becomes more serious when the positioner adopts a specific posture. - If the operating speed of the positioner is reduced, vibration stops. - Vibration is most noticeable when the positioner is accelerating.	[Overload] - It is likely that the load on the positioner is greater than the maximum rating. - It is likely that the positioner control program is too demanding for the positioner hardware. - It is likely that the ACCELERATION value is excessive.	- Check the maximum load that the positioner can handle once more. If the positioner is found to be overloaded, reduce the load, or modify the positioner control program. - Vibration in a specific portion can be reduced by modifying the positioner control program while slowing the positioner and reducing its acceleration (to minimize the influence on the entire cycle time).

Symptom	Description	Cause	Measure
Vibration Noise (Continued)	- Vibration was first noticed after the positioner collided with an object or the positioner was overloaded for a long period. - The grease of the vibrating axis has not been replaced for a long period. - Cyclical vibration and noise occur.	[Gear, bearing, or reducer] - It is likely that collision or overload applied an excessive force on the drive mechanism, thus damaging the tooth surface or rolling contact surface of a bearing, or reducer. - Prolonged overloaded use may cause fretting fatigue on the gear tooth surface or the rolling surface of bearing and reducer. - It is likely that foreign material caught in a gear, bearing, or within a reducer caused damage on the tooth surface or rolling contact surface of the bearing, or reducer. - It is likely that foreign material caught in a gear, bearing, or within a reducer cause vibration. - It is likely that, because the grease has not been changed for a long period, fretting occurred on the tooth surface or rolling contact surface of a bearing, or reducer due to metal fatigue.	- Remove the motor, and replace the gear, the bearing, and the reducer. For the spec. of parts and the method of replacement, contact FANUC. - Using the positioner within its maximum rating prevents problems with the drive mechanism. - Using the specified grease oil at the recommended interval will prevent problems

Symptom	Description	Cause	Measure
Vibration Noise (Continued)	- The cause of problem cannot be identified from examination of the floor, rack, or mechanical section.	[Controller, cable, and motor] - If a failure occurs in a controller circuit, preventing control commands from being supplied to the motor normally, or preventing motor information from being sent to the controller normally, vibration might occur. - Pulsecoder defect may be the cause of the vibration as the motor cannot propagate the accurate position to the controller. - If the motor becomes defective, vibration might occur because the motor cannot deliver its rated performance. - If the positioner connection cable has an intermittent break, vibration might occur. - If the power supply cable is about to be snapped, vibration might occur. - If the power source voltage drops below the rating, vibration might occur. - It may vibrate when the invalid value parameter was set.	- Refer to the Controller Maintenance Manual for troubleshooting related to the controller and amplifier. - Replace the motor of the axis that is vibrating, and check whether vibration still occurs. To replace the motor, Contact your local FANUC representative. - Check whether the jacket of the positioner connection cable is damaged. If so, replace the cable, and check whether vibration still occurs. - Check whether the jacket of the power cable is damaged. If so, replace the power cable, and check whether vibration still occurs. - Check that the positioner is supplied with the rated voltage. - Check that the robot control parameter is set to a valid value. If it is set to an invalid value, correct them. Contact your local FANUC representative for further information if necessary.

Symptom	Description	Cause	Measure
Vibration Noise (Continued)	- There is some relationship between the vibration of the positioner and the operation of a machine near the positioner.	[Noise from a nearby machine] - If the positioner is not grounded properly, electrical noise is induced on the grounding wire, preventing commands from being transferred accurately, thus leading to vibration. - If the positioner is grounded at an unsuitable point, its grounding potential becomes unstable, and noise is likely to be induced on the grounding line, thus leading to vibration.	- Connect the grounding wire firmly to ensure a reliable ground potential and prevent extraneous electrical noise.
	- There is an unusual sound after replacement of grease. - There is an unusual sound after a long period. - There is an unusual sound during operation at low speed.	- There may be an unusual sound when using other than the specified grease. - Even for the specified grease, there may be an unusual sound during operation at low speed immediately after replacement or after a long period.	- Use the specified grease. - When there is an abnormal noise even when using the specified grease, operate for one or two days as an experiment. Generally, any abnormal noise will disappear.

Rattling	- While the positioner is not supplied with power, pushing it with the hand causes part of the mechanical unit to wobble.
	- There is a gap on the mounting face of the mechanical unit.
		[Mechanical section coupling bolt]
		- It is likely that overloading or a collision has loosened a mounting bolt in the positioner mechanical section.
			- Check that the following bolts for each axis are tight. If any of these bolts is loose, apply LOCTITE and tighten it to the appropriate torque.
			  - Motor retaining bolt
			  - Reducer retaining bolt
			  - Reducer shaft retaining bolt
			  - Base retaining bolt
			  - Equipment retaining bolt

Symptom	Description	Cause	Measure
Motor overheating	- The ambient temperature of the installation location increases, causing the motor to overheat. - After a cover was attached to the motor, the motor overheated. - After the positioner control program or the load was changed, the motor overheated.	[Ambient temperature] - It is likely that the motor overheated along with the ambient temperature rose, and could not release heat. [Operating condition] - It is likely that the overcurrent above the specified permissive average current.	- Reducing the ambient temperature is the most effective means of preventing overheat. - Having the surroundings of the motor well ventilated enables the motor to release heat efficiently, thus preventing overheat. - If there is a source of heat near, it is advisable to install shielding to protect the motor from heat radiation. - Relaxing the positioner control program and load condition is effective to reduce the average current. Thus, prevent overheat. - The teach pendant can monitor the average current. Check the average current when the positioner control program launched.
	- After a positioner control parameter (load setting etc.) was changed, the motor overheated.	[Parameter] - If data input for a workpiece is invalid, the positioner cannot be accelerated or decelerated normally, so the average current increases, leading to overheat.	- As for load setting, Input an appropriate parameter referring to Section 4.2.
	- Symptom other than stated above	[Mechanical section problems] - It is likely that problems occurred in the mechanical unit drive mechanism, thus placing an excessive load on the motor. [Motor problems] - It is likely that a failure of the motor brake resulted in the motor running with the brake applied, thus placing an excessive load on the motor. - It is likely that a failure of the motor prevented it from delivering its rated performance, thus causing an excessive current to flow through the motor.	- Repair the mechanical unit while referring to the above descriptions of vibration, noise, and rattling. - Check that, when the servo system is energized, the brake is released. If the brake remains applied to the motor all the time, replace the motor. - If the average current falls after the motor is replaced, it indicates that the first motor was faulty.

Symptom	Description	Cause	Measure
Grease leakage	- Grease l is leaking from the mechanical unit.	[Poor sealing] - Probable cause is a crack in the casting, a broken O-ring, a damaged oil seal, or a loose seal bolt. - A crack in a casting can occur due to excessive force that might be caused in collision. - An O-ring can be damaged if it is trapped or cut during disassembling or re-assembling. - An oil seal might be damaged if extraneous dust scratches the lip of the oil seal. - A loose seal bolt or a taper plug might allow grease to leak along the threads.	- If a crack develops exist in the casting, sealant can be used as a quick-fix to prevent further grease leakage. However, the component should be replaced as soon as possible, because the crack might propagate. - O-rings are used in the locations listed below. - Motor coupling section - Reducer (case and shaft) coupling section - Oil seals are used in the locations stated below. - Inside the reducer - Seal bolts and taper plugs are used in the locations stated below. - Grease inlet or outlet
Rotation of axis	- Axis rotates because the brake does not function. - An axis rotates gradually when it should be at rest.	[Brake drive relay and motor] - It is likely that brake drive relay contacts are stuck to each other to keep the brake current flowing, thus preventing the brake from operating when the motor is reenergized. - It is likely that the brake shoe has worn out or the brake main body is damaged, preventing the brake from operating efficiently. - It is likely that oil or grease has entered the motor, causing the brake to slip.	- Check whether the brake drive relay contacts are stuck to each other. If they are found to be stuck, replace the relay. - Replace the motor after confirming whether the following symptoms have occurred. - Brake shoe is worn out - Brake main body is damaged - Oil or grease soaked through the motor

Symptom	Description	Cause	Measure
Displace-ment	- The positioner operates at a point other than the taught position. - The repeatability is not within the tolerance.	[Mechanical section problems] - If the repeatability is unstable, probable cause is a failure in the drive mechanism or a loose bolt. - If the repeatability becomes stable, it is likely that a collision imposed an excessive load, leading to slipping on the base surface or the mating surface of a reducer. - It is likely that the Pulsecoder is faulty.	- If the repeatability is unstable, repair the mechanical section by referring to the above descriptions of vibration, noise, and rattling. - If the repeatability is stable, correct the taught program. The problem will not occur unless another collision occurs. - If the Pulsecoder is faulty, replace the motor.
	- Displacement occurs only in specific peripheral equipment.	[Peripheral equipment displacement] - It is likely that an external force was applied to the peripheral equipment, thus shifting its position relative to the positioner.	- Correct the setting of the peripheral equipment position. - Correct the taught program.
	- Displacement occurred after a parameter was changed.	[Parameter] - It is likely that the mastering data was rewritten in such a way that the positioner origin was shifted.	- Re-enter the previous mastering data, which is known to be correct. - If correct mastering data is unavailable, perform mastering again.
BZAL alarm occurred	- BZAL is displayed on the teach pendant screen.	- It is likely that the voltage of the memory backup battery is low. - It is likely that the Pulsecoder cable is defective. - If the Connector option is not ordered, this alarm will be issued for the first time.	- Replace the battery. - Replace the cable. - Pulse reset. (Please see 8.2 section)

APPENDIX

A PERIODIC INSPECTION TABLE

FANUC 1-axis POSITIONER **PERIODIC MAINTENANCE TABLE**

Item		Accumulated operating time (H) / Check time	Check time	Grease amount	First check 320	3 months 960	6 months 1920	9 months 2880	1 year 3840	4800	5760	6720	2 years 7680	8640	9600	10560
Mechanical unit	1	Check for external damage or peeling paint	0.1H	—		○	○	○	○	○	○	○	○	○	○	○
	2	Check for water	0.1H	—		○	○	○	○	○	○	○	○	○	○	○
	3	Check the motor connector (tightness) *3	0.2H	—		○			○				○			
	4	Tighten the flange mounting bolts, cover mounting bolts, and main bolts	0.7H	—		○			○				○			
	5	Clean spatters, sawdust and dust	1.0H	—		○			○				○			
	6	Replacing batteries *2 *4	0.1H	—							●					
	7	Replacing grease of reducer	5.0H	19000ml												
Controller	8	Check the robot cable, teach pendant cable and robot connecting cable	0.2H			○			○				○			
	9	Cleaning the controller ventilation system	0.2H		○	○	○	○	○	○	○	○	○	○	○	○
	10	Replacing batteries *1 *4	0.1H													

*1 Refer to the “REPLACING UNITS Chapter of MAINTENANCE” in the following manuals.
R-30*i*B/R-30*i*B Plus CONTROLLER MAINTENANCE MANUAL (B-83195EN) etc.
●: requires order of parts
○: does not require order of parts

*2 Check this when Connector option is selected.

*3 The cycle of replacing is necessary to be shortened. Contact your local FANUC representative for the cable replacing method.

*4 Regardless of the operating time, replace the mechanical unit batteries at 1 year, replace controller batteries at 4 years.

3 years 11520	12480	13440	14400	4 years 15360	16320	17280	18240	5 years 19200	20160	21120	22080	6 years 23040	24000	24960	25920	7 years 26880	27840	28800	29760	8 years 30720	Items
○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	Overhaul	1
○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		2
○				○				○				○				○					3
○				○				○				○				○					4
○				○				○				○				○					5
●						●						●						●			6
●												●									7
○				○				○				○				○					8
○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		9
				●																	10

B STRENGTH OF BOLT AND BOLT TORQUE LIST

NOTE

When applying LOCTITE to a part, spread the LOCTITE on the entire length of the engaging part of the female thread. If applied to the male threads, poor adhesion can occur, potentially loosening the bolt. Clean the bolts and the threaded holes and wipe off any oil on the engaging section. Make sure that there is no solvent left in the threaded holes. When finished, remove all the excess LOCTITE when you are finished screwing the bolts into the threaded holes.

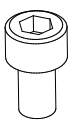
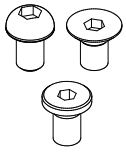
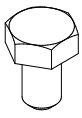
Use the following strength bolts. Comply with any bolt specification instructions.
Hexagon socket head bolt made of steel:

Size M22 or less: Tensile strength 1200N/mm^2 or more
Size M24 or more: Tensile strength 1000N/mm^2 or more
All size plating bolt: Tensile strength 1000N/mm^2 or more

Hexagon bolt, stainless bolt, special shape bolt (button bolt, low-head bolt, flush bolt .etc.)
Tensile strength 400N/mm^2 or more

Refer to the following tables if the bolts tightening torque are not specified.

Recommended bolt tightening torques **Unit: Nm**

Nominal diameter	Hexagon socket head bolt (steel)		Hexagon socket head bolt (stainless steel)		Hexagon socket head button bolt Hexagon socket head flush bolt Low-head bolt (steel)		Hexagon bolt (steel)	
	Tightening torque		Tightening torque		Tightening torque		Tightening torque	
	Upper limit	Lower limit	Upper limit	Lower limit	Upper limit	Lower limit	Upper limit	Lower limit
M3	1.8	1.3	0.76	0.53	———	———	———	———
M4	4.0	2.8	1.8	1.3	1.8	1.3	1.7	1.2
M5	7.9	5.6	3.4	2.5	4.0	2.8	3.2	2.3
M6	14	9.6	5.8	4.1	7.9	5.6	5.5	3.8
M8	32	23	14	9.8	14	9.6	13	9.3
M10	66	46	27	19	32	23	26	19
M12	110	78	48	33	———	———	45	31
(M14)	180	130	76	53	———	———	73	51
M16	270	190	120	82	———	———	98	69
(M18)	380	260	160	110	———	———	140	96
M20	530	370	230	160	———	———	190	130
(M22)	730	510	———	———	———	———	———	———
M24	930	650	———	———	———	———	———	———
(M27)	1400	960	———	———	———	———	———	———
M30	1800	1300	———	———	———	———	———	———
M36	3200	2300	———	———	———	———	———	———
								

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