NACHI

MAINTENANCE SERVICE MANUAL

ST-F-01 series [AX20]

8th edition

	■ Before attempting to operate the robot, please read through this operating manual carefully, and comply with all the safety-related items and instructions in the text. ■ The installation, operation and maintenance of this robot should be undertaken only by those individuals who have attended one of our robot courses.
	■ This operating manual must be given without fail to the individuals who will actually be operating the robot.
	■ Please direct any in queries about parts of this operating manual which may not be completely clear or any inquiries concerning the after-sale service of this robot to any of the service centers of Nachi Robotic Systems listed on the back cover.

NACHI-FUJIKOSHI CORP.

1108, MSTEN-208-008, 001

Table of Contents

Introduction

This manual explains the robot specifications, structure of each part and the basic handling precautions for inspection and maintenance to maintain function of the robot for a long period.
It is recommended that this manual is read by robot utilization planners and installation staff as well as inspectors and maintenance staff for robot operation and the robot is handled only after understanding this manual completely.

This manual may be modified without notice for robot improvement.

For safe use of the robot

Read this section carefully prior to installation, operation, maintenance, or inspection and use equipment correctly. Use the robot only after fully understanding the equipment, all safety points, and comments/suggestions. The following table shows the importance of the following tags/marks in this Operation manual:

DANGER	Case where a mistake made in handling is likely to cause the user to be exposed to the danger of death or serious injury and where the degree of the urgency (imminence) of the warning given for the danger to occur is at the high end of the scales (including high-level danger).
WARNING	Cases where a mistake made in handling is likely to cause the user to be exposed to the danger of death or serious injury.
CAUTION	Cases where a mistake made in handling is likely to cause the user to be exposed to the danger of minor injuries or of property damage only.

And, the other notes use a mark like the one shown as below.

	This indicates the other special notes.

Precautions when performing adjustment, operation or maintenance

1. Operators must wear overalls, helmets, safety glasses and safety shoes.
2. Make sure there is no one in the robot work area when the power is turned ON.
3. Only perform work within the robot work area after making sure the motor power is OFF.
4. In cases where inspection or maintenance work has to be done with motor power ON, perform the work in pairs. One person must stand guard and ready to press an emergency stop button. The other person must work quickly and carefully within the robot operating area. Always allocate, confirm and know an escape route prior to beginning work.
5. Do not disassemble counter balancers!! They contain highly compressed powerful springs.
6. Ensure payload on the wrist and forearm is within specifications. Excessive loads may cause poor robot operation and eventually damage the robot.
7. Read “Points on safety” in the “INSTALLATION” manual.
8. Do not disassemble or operate any part that is not explained in the Maintenance manuals.

It is possible the robot will make an emergency/safe stop if an abnormal situation occurs, this is due to various self-diagnostic functions and abnormality detecting functions provided. However, the robot is not 100% safe.

DANGER

Robot accidents that occurred in the past were mostly due to the following situations:

- **Auto operation started without confirming there were no workers within the robot operating area.**
- **People being within the robot operating area when the robot was in auto operation mode and the robot unexpectedly started.**
- **People carefully watching one robot but forgetting another one was operating within reach of them.**

Carelessness attributed to the above accidents are:

- **Safety procedures were neglected.**
- **Robot suddenly started even though it was thought the robot could not be started.**

We can summarize the above as **unsafe activities caused by human error such as "careless mistakes" and "not following the established procedures."** Workers not be able to take appropriate actions, such as "emergency stop" or "escape from the danger", when unexpected robot motion occurs which may result in disastrous accidents.

Unexpected robot motion includes:

∗ Sudden change of movement from low speed to high speed.
∗ Manipulation by another worker.
∗ Robot operated by a different program due to program mistakes or faulty peripheral equipment.
∗ Abnormal behavior due to noise, faults or errors.
∗ Mishandling.
∗ Operation at a high speed in spite of intended low speed playback.
∗ Work-piece being handled by the robot is dropped or thrown.
∗ Work-piece is suddenly released during a stop waiting for interlocking.
∗ Adjacent or rear robots started operation unexpectedly.

The above are a few examples, there are of course many other unexpected robot motion patterns. It may be impossible to stop a robot or escape from a robot that started unexpectedly. The best way to avoid such accidents is;

DANGER

"Do not get near the robot under unprepared condition".

DANGER

When the robot is not used, take the measures, such as pressing the Emergency Stop button or turning off the power supply, to prevent the robot from operating unexpectedly.

DANGER

During the robot's operation, have a watcher (the third person), standby at a position where he or she can supervise safety of the work area and press the Emergency Stop button immediately.

DANGER

During robot operation, conduct work ready to press an Emergency Stop button at any time.

In order to follow these rules, it is necessary to thoroughly understand the cautions described hereafter and follow them precisely.

Safety measures for robot

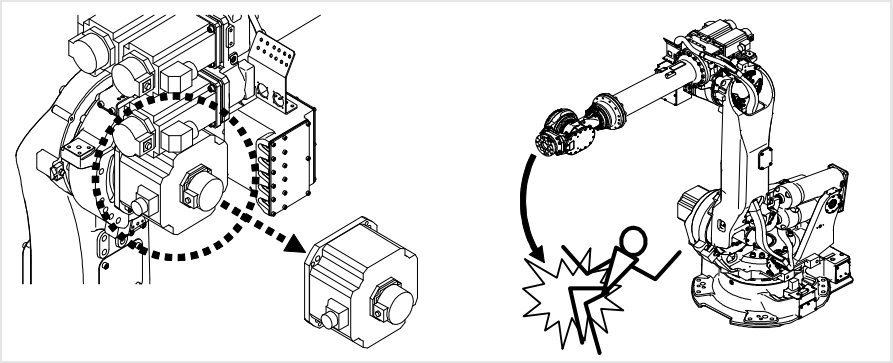
The robot is of such design that no unnecessary protrusions or sharp corners exist. It is made of suitable material for use in the environment for which it was designed and has fail-safe construction to minimize damage or accidents during operation. The robot maintains a good level of safety because various safety functions exist; such as those to detect incorrect operation and stop the robot, or to make emergency stops, inter-locking with peripheral equipment, when either device threatens to damage the other.

WARNING

The robot is of multi-articular arm construction, thus each articular angle varies all the time with robot movement. Take care and avoid getting pinched in various articulations, especially when teaching. Pay careful attention to the stopper blocks mounted on the moving tip of the articulations. The arm may fall under its own weight when motors are removed or brakes are released. Therefore take action to prevent dropping and check that conditions are safe before starting work.

WARNING

The motors in this robot have built-in brakes to hold the robot arm in position. As such, when a motor is removed without supporting the arm properly, the arm may drop or move forward or backward. PROPERLY SUPPROT THE ARM BEFORE REMOVING THE MOTOR.



If the motor is removed without proper support... **The robot arm will drop or move forward or backward!**

To prevent the arm from dropping, use a wooden block, nylon sling, crane or other means to support the arm securely before removing the motor. The zeroing pins and zeroing blocks are used for zero position alignment and not for supporting the arm. And, do not support the robot arm by a human's hand.

CAUTION

Never remove or disassemble a balance unit as it contains highly compressed powerful springs inside. Removal is a very dangerous act.

(only for the machines which equips balance unit)

CAUTION

Use specified bolt sizes and number. Tighten them to specified torque with a torque wrench when fitting equipment onto the end effecter flange or arms. Use clean rust-free bolts. Otherwise bolts may loosen during operation causing serious accidents and injuries.

CAUTION

When fabricating the end effecter, set its weight, static torque and the moment of inertia within the range of the permissible load levels of the robot wrist.

CAUTION

Provide a failsafe construction which will ensure that the work gripped will not be released or scattered even when the power or air supply to the end effector is cut off. Also remove any sharp edges or protrusions in its construction to prevent injury to personnel and damage to property.

CAUTION

In order to operate the robot, services such as electric power, plant air and cooling water for welding should be supplied. However, services out of specification may effect the robot performance and cause abnormal behavior, errors, or damage, resulting in dangerous situations. Never use unspecified resources.

CAUTION

It is not possible to eliminate electromagnetic interference completely using the technology available today although the extent of its elimination depends on the type and strength of the interference concerned. In terms of what action to take while the robot is operating and while the power is ON, follow the precautions to be observed during operation. In some cases, electromagnetic waves, other forms of noise or defective circuit boards may erase the recorded work programs. As a safeguard, make backups of the programs, constants, etc. on a Compact Flash card or other media.

Safety measures in teaching (programming) and inspection

Observe the following points while conducting “teaching” or inspection of the robot according to specified procedures.

CAUTION

Robot operators must only be those who have **completed specified robot training** and are fully aware of safety and functions of Nachi robots. Accidents may occur due to mishandling of the robot during operation by those who do not know correct procedures well.

CAUTION

When entering a robot operating area with Motors-on, the emergency stop button must be readily accessible. In addition, a watcher must be present outside the operating area ready to press the emergency button immediately. In doing so an emergency stop can be made quickly.

WARNING

Wear protective gear such as a **helmet and safety boots, etc,** when operating the robot or entering its operating area. If this rule is not kept, because of e.g. miss-operation of the robot etc., disastrous accidents may occur.

WARNING

Keep the robots “**Key Switch**” and a safety plug for changing to Auto operation **with you** when entering the robot operating area so other people **cannot** change the switch to Auto operation accidentally. If the key is left in the switch other workers may accidentally start Auto operation leading to serious accidents.

WARNING

Display (attach) a sign showing **"Teaching Under Way"** on the operation panel when teaching. Other workers are required to notice this fact. If not, they may start the Auto operation, resulting in serious or fatal accidents.

CAUTION

When a number of workers are involved in the teaching of a robot the **operator holding the Teach Pendant** is in charge and must give commands and the others must follow. Commands given by numerous operators invites incorrect manipulation, leading to accidents.

CAUTION

Consider method to communicate with other workers such as **hand signals** when conversation takes place between a number of workers positioned separately, in a large system (plant) for example. Accidents are likely to occur due to misinterpreted intentions in a noisy site.

Examples of hand signals for industrial robot operation

1.Switch ON  Act like pressing a switch.	2.Switch OFF  Raise the right hand high and then swing it left and right clearly.
3.OK ? (Confirmation)  Raise the right hand high with palm facing forward.	4.OK !  Raise the right hand high with palm facing forward and thumb and index finger creating a circle.
5.Wait !  Face the right hand palm forward with its arm extended horizontally.	6.Go away !  Extend the right hand horizontally and swing it to the left.

CAUTION

Keep a **safe place (escape route)** in mind at all times to quickly escape on an emergency.

WARNING

Pay attention to the robot's movement at all times and never work with **your back toward** the robot. An operator may not notice the start of robot if he/she is not facing it resulting in an accident.

WARNING

Press the **emergency stop button immediately** if you notice any abnormality. Make this practice very clear to every operator. A sudden movement may be imminent if you are watching something abnormal.

CAUTION

Prepare an appropriate **working codes and checklists** for start up of the robot, how to operate it and what actions to take in an emergency. Proceed with operation according to the working code. Accidents are likely to occur due to forgetfulness and error of operators if relying on memory alone.

CAUTION

Proceed with work with the robot's **power OFF** when operation or manipulation of the robot are not necessary. It can never run with its power OFF.

CAUTION

When teaching, always check the **program number and step number** before operating the robot. Editing of incorrect programs or steps may cause accidents.

CAUTION

Protect completed programs from accidental editing by using the **memory protect function**. (The memory protect function disabling the editing of various programs and constants is available on this robot controller.)

CAUTION

Check robot movement at a low speed using the **check go/back function and the velocity override function** after completing teaching. Accidents due to collision are likely to occur if a program containing a mistake is run at a 100% of full speed in the playback mode.

CAUTION

Clean the area within the guard fence and check that tools, etc. are not left there after teaching is complete. A workplace fouled with oil or grease and tools is a hazardous place and may lead to an accident due to stumbling.

"**Cleaning the workplace**" is a step toward safety.

Safety measures in test run

In the test run, design errors, programming errors or manufacturing errors may exist in addition to errors in the program point positions, fixture operation, sequences, etc. Therefore, safety consciousness during the test run should be increased. Perform test run giving careful attention to the following points;

WARNING

Check all buttons to stop the robot, such as emergency stop button and other stop buttons, and that their signals work well. Then check the functions associated with detection of abnormalities. **Confirmation of "stop" is most important.** Accident or injury may result due to the failure of a stop button or signal in an emergency.

CAUTION

When performing the test run, start the robot up at a low speed (about 5% to 10%), with the velocity override function, **to check the movement at a low speed**. Repeat this about 2 to 3 cycles. Correct any errors, if any, at once. Then gradually increase the speed (50% - 70% - 100%) and repeat 2 to 3 cycles at each speed to confirm the movement. It is difficult to stop a robot, when an error occurs, before it causes damage if checking is started at a full speed.

DANGER

Confirmation of the program should **NEVER** be made from within the guard fence as unexpected things may occur in the test run. The test run stage is one of low predictability, thus a high probability of unexpected accidents exists.

Auto operation

CAUTION

Clean the workplace and keep everything in order at the beginning and end of work. If the workplace is littered with various items, accidents, such as tripping, may occur.

CAUTION

Ensure **daily inspections according to the specified checklist** is done before startup. By discovering abnormalities in advance, accidents can be avoided. (Refer to Maintenance Manual for the daily inspection items. It is mandatory to check all of the items in the checklist prepared based on the above Maintenance Manual.)

CAUTION

An "**OFF LIMITS**" sign should be displayed at all entrances of the guard fence and all employees made aware of this rule. If not, they may enter the guard fence thinking that the robot is inoperable.

DANGER

Always confirm there is no one within the guard fence before starting auto operation. Accidents caused by neglecting to confirm a **persons presence** are the most typical.

CAUTION

Start auto operation after confirming the program number, step number, mode and startup select are all **ready for auto operation**. If a robot is started with an incorrect program or step selected, unexpected incorrect movement may occur resulting in an accident.

CAUTION

Check that the robot is **in a good position to start for auto operation**. Check the program number and the step number match the current robot position. If the robot is in an incorrect position, even though the program and step are OK, it will act differently, resulting in a probable accident.

CAUTION

Before Start up, make sure the **Emergency stop button can be pressed immediately**. This is vital in dealing with unexpected occurrences.

CAUTION

Operators should be familiarized with the robot's **movement path, operating behavior, running sound**, etc. so that abnormalities can be detected. Failures may be avoided by recognizing abnormal behavior as abnormalities usually indicate an imminent system failure. In order to detect these operators need to be fully aware of the normal status of operation.

WARNING

Make an **Emergency stop immediately** if any abnormal behavior is observed and report the incident to superiors or the person in charge of maintenance, and take appropriate action. The "It looks strange, but moving. That's OK" attitude can cause not only a stop in production due to failure but serious injury.

WARNING

When verifying operation after remedial measures have been taken to deal with the occurrence of fault, refrain from conducting any operations such as conducting low-speed playback to verify operation while an operator is still inside the guard fence until it is **confirmed that the fault has indeed been remedied**. What will happen in this kind of situation cannot be reliably predicted so other fault may occur or unforeseen accidents may result.

Movement, alienation and selling of robot

CAUTION

Hand over all manuals and documents received when purchasing the robot to the new owner when moving, alienating or selling a robot. In particular, if the robot is to be moved, transferred or sold overseas, the user is responsible for preparing and supplying the operating maintenance manuals in the appropriate language, amending the language used for the labels and displays and complying with the laws of the country concerned. Accidents may occur if the new robot owner (operator) operates the robot incorrectly or performs unsafe work tasks due to not receiving and reading the Operating Instructions.

CAUTION

When the robot is moved, transferred or sold (either in the country or overseas) by the user, whatever was agreed upon at the time of the robot's initial sale inclusive of the safety related items is not transferable to the new owner unless a special agreement has been concluded. The user must conclude a new agreement with the new owner.

Scrapping the robot

CAUTION

Do not disassemble, heat or burn batteries used in the controller and robot as they may catch fire, burst or burn.

CAUTION

Do not disassemble the controller in detail smaller than PCBs or units. Sharp edges or electric wire of small disassembled pieces may cause injury.

CAUTION

Do not disassemble wire harnesses or manipulator wiring further than disconnecting wiring from connectors or terminal blocks. Disassembled pieces, e.g. conductors, etc., may cause injury to hands or eyes.

CAUTION

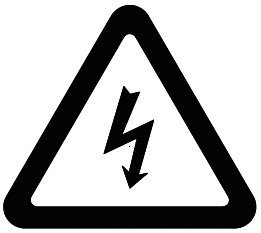
Use extreme care when scrapping so as to avoid accidents and injury such as pinching hands or fingers.

CAUTION

Discard scrapped items safely to avoid injury.

Labels and marks on manipulator and controller

Supplementary explanation is made below concerning labels and warning plates attached to the manipulator and controller.

	This mark indicates a power supply unit and danger of electric shock. This is displayed at the primary power inlet, the cover of the transformer space on the controller and at the harness connection of the robot.

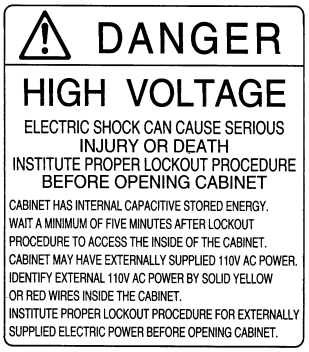
CAUTION

Under a cover displaying this mark on the controller, a primary power voltage (AC 200V to AC 480V) exists, which may cause serious electric shock. Turn OFF the power at both the controller breaker and the power distribution panel when doing maintenance requiring the removal of any of these covers.

DANGER

This mark also indicates a power supply inlet for the robot. Motor power and detector unit power is supplied to connectors and terminal blocks under various connector covers on the robot baring this mark.

Do not touch connectors or terminal blocks directly or indirectly with conductive items with mains power supplied, as electric shock may occur. If connectors or terminal blocks are removed with mains power on, electric shock or malfunction of the robot may result. Turn OFF main power on the controller when performing any maintenance.

	This label indicates a high voltage. Use caution when touching units carrying this label. Electrically charged parts in the controller exist even after the main power is turned OFF. Therefore it is very dangerous (i.e. electric shock) to touch them too soon after turning OFF the main power.

CAUTION

Wait 5 minutes after turning OFF the main power before working inside the controller. Do not work with wet hands otherwise electric shock may result. It parts get wet, it may lead to a malfunction or failure.

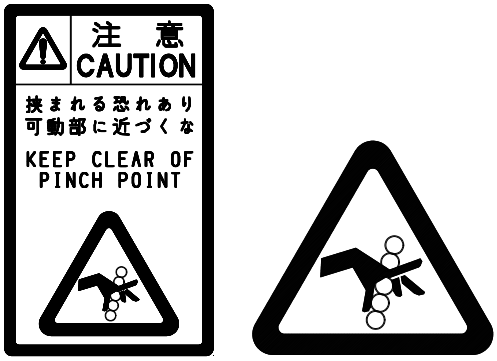
CAUTION

Replace controller units (parts) according to procedures given in the AX Controller teach pendant electronic manual. Incorrect removal and installation may result in a malfunction, failure or accident.

	This mark indicates hot parts on the robot.

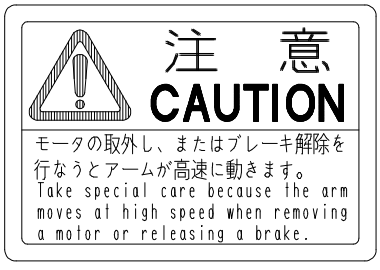
CAUTION

Check that the part bearing this mark is not hot before touching it. Carelessly touching labeled hot parts may result in serious burns.

	This mark indicates area operators may get caught by the robot.

CAUTION

Places bearing this mark should never be touched. Brakes can be released not only during teaching but also while the motors are OFF. Take adequate steps to prevent your hands or other parts of your body from being pinched when these areas are touched during maintenance work, etc.

	This label indicates that robot arms may fall when releasing a brake or motors are removed from the robot.

CAUTION

The arm driven by the motor being removed will drop if not restrained. When releasing a brake, the arm falls. Never put yourself under the arm when releasing a brake or motors are removed from the robot.

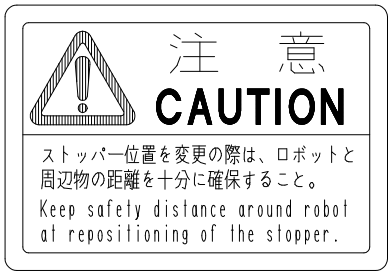
CAUTION

Dismounting the motor from the robot without properly supporting the arm can cause the arm to drop or move forward or backward. Be sure to properly support the arm before dismounting the motor. After inserting a location pin, to prevent the arm from dropping, support the arm using wooden blocks or a crane, and then dismount the motor from the robot. (Note that the location pin and blocks are used for the home position adjustment, not for supporting the arm.)
Furthermore, NEVER attempt to hold the robot arm with hands.

This label warns of stored energy. Therefore use caution when disassembling the robot units labeled as such.

CAUTION

Never disassemble the parts bearing this mark, even when disassembling the robot during robot maintenance. Disassembly of these parts may cause fatal or serious accidents.



This label indicates that robot arms may fall when stoppers are removed from the robot.

CAUTION

Do not operate the robot without mechanical stoppers. Such a operation may cause a damage to the peripheral equipments or result serious injury or death.

This label indicates covers where motor plug is protected.

(only for available robot and axis)

CAUTION

Do not get on the part where this mark is attached, and work while putting strong power.
There is a possibility that the cover and the plug are damaged.

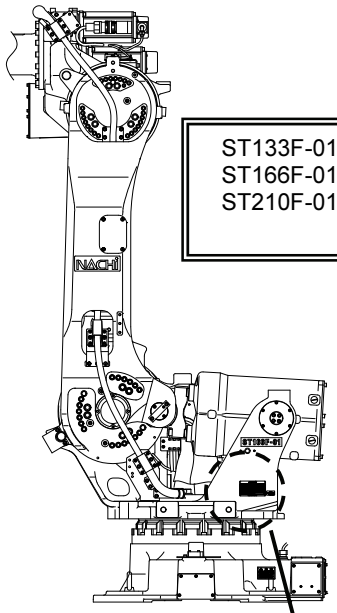
NOTE

Chapter 1 Basic specifications

1.1 Robot model and nameplate details

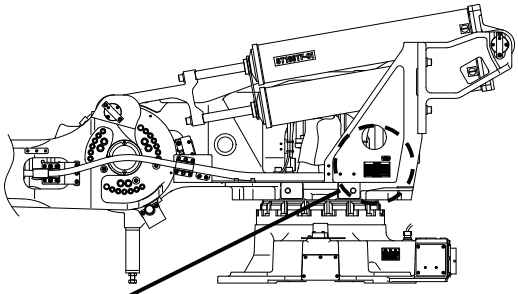
ST 133 T F – 01

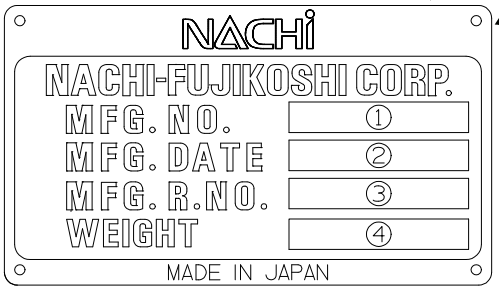
- 01 : Specification No.
- F : Series name
- T : Robot type (none : floor mounting / T : Shelf mounting)
- 133 : Pay load
- ST : Series name



ST133F-01
ST166F-01
ST210F-01

ST133TF-01
ST166TF-01
ST210TF-01





(1) MFG.NO. ····· Manufacturing number
(2) MFG.DATE ····· Date of manufacture
(3) MFG.R.NO. ····· Serial robot number
(4) WEIGHT ····· Mass of robot
(The item (4) is only adaptable to CE specification.)

1.2 List of basic specifications

Floor mounting type

Item		Specification		
Robot model		ST133F-01	ST166F-01	ST210F-01
Construction		Articulated construction		
Degrees of freedom		6		
Drive system		AC servo system		
Max. Operating range	J1	±3.14 rad (±180°)		
	J2	-1.40 ～ +1.05 rad (-80 ～ +60°)		
	J3	-2.40 ～ +2.62 rad (-137 ～ +150°)		
	J4	±6.28 rad (±360°)		
	J5	±2.36 rad (±135°)		±2.27 rad (±130°)
	J6	±6.28 rad (±360°)		
Max. speed	J1	2.27 rad/s (130° /s)	1.92 rad/s (110° /s)	1.75 rad/s (100° /s)
	J2	2.27 rad/s (130° /s)	1.92 rad/s (110° /s)	1.57 rad/s (90° /s)
	J3	2.27 rad/s (130° /s)	1.92 rad/s (110° /s)	1.66 rad/s (95° /s)
	J4	4.01 rad/s (230° /s)	2.97 rad/s (170° /s)	2.27 rad/s (130° /s)
	J5	4.01 rad/s (230° /s)	2.97 rad/s (170° /s)	2.27 rad/s (130° /s)
	J6	5.32 rad/s (305° /s)	4.54 rad/s (260° /s)	3.49 rad/s (200° /s)
Max. pay Load	Wrist	133 kg	166 kg	210 kg
	Upper part of Forearm *1)	45 kg (90kg at maximum)		
Allowable static load torque of wrist	J4	745 N·m	951 N·m	1,337 N·m
	J5	745 N·m	951 N·m	1,337 N·m
	J6	411 N·m	490 N·m	720 N·m
Max. allowable moment of inertia of wrist *2)	J4	60.9 kg·m^2	88.9 kg·m^2	141.1 kg·m^2
	J5	60.9 kg·m^2	88.9 kg·m^2	141.1 kg·m^2
	J6	30.2 kg·m^2	45.0 kg·m^2	79.0 kg·m^2
Position repeatability *3)		±0.2 mm		±0.3 mm
Ambient temperature		0 ～ 45 °C		
Ambient humidity		20 ～ 85 %RH (No dew condensation is allowed)		
Vibration value		0.5 G or less		
Robot type		Floor mounting		
Robot mass		1,070 kg		1,110 kg

1[rad] = 180/π[°], 1[N-m] = 1/9.8[kgf·m]

*1) Note that this load varies depending on its mounting position and the weight of wrist payload.

*2) Note that the allowable moment of inertia of wrist varies with the wrist load conditions.

*3) Note that this value is determined under the rule of JIS B 8432.

Shelf mounting type

Item		Specification		
Robot model		ST133TF-01	ST166TF-01	ST210TF-01
Construction		Articulated construction		
Degrees of freedom		6		
Drive system		AC servo system		
Max. Operating range	J1	±3.14 rad (±180°)		
	J2	-1.13 ～ +2.09 rad (-65 ～ +120°)		
	J3	-1.85 ～ +3.67 rad (-106 ～ +210°)		
	J4	±6.28 rad (±360°)		
	J5	±2.36 rad (±135°)		±2.27 rad (±130°)
	J6	±6.28 rad (±360°)		
Max. speed	J1	2.27 rad/s (130° /s)	1.92 rad/s (110° /s)	1.75 rad/s (100° /s)
	J2	2.27 rad/s (130° /s)	1.92 rad/s (110° /s)	1.57 rad/s (90° /s)
	J3	2.27 rad/s (130° /s)	1.92 rad/s (110° /s)	1.66 rad/s (95° /s)
	J4	4.01 rad/s (230° /s)	2.97 rad/s (170° /s)	2.27 rad/s (130° /s)
	J5	4.01 rad/s (230° /s)	2.97 rad/s (170° /s)	2.27 rad/s (130° /s)
	J6	5.32 rad/s (305° /s)	4.54 rad/s (260° /s)	3.49 rad/s (200° /s)
Max. pay Load	Wrist	133 kg	166 kg	210 kg
	Upper part of Forearm *1)	45 kg (90kg at maximum)		
Allowable static load torque of wrist	J4	745 N·m	951 N·m	1,337 N·m
	J5	745 N·m	951 N·m	1,337 N·m
	J6	411 N·m	490 N·m	720 N·m
Max. allowable moment of inertia of wrist *2)	J4	60.9 kg·m^2	88.9 kg·m^2	141.1 kg·m^2
	J5	60.9 kg·m^2	88.9 kg·m^2	141.1 kg·m^2
	J6	30.2 kg·m^2	45.0 kg·m^2	79.0 kg·m^2
Position repeatability *3)		±0.2 mm		±0.3 mm
Ambient temperature		0 ～ 45 ℃		
Ambient humidity		20 ～ 85 %RH (No dew condensation is allowed)		
Vibration value		0.5 G 以下		
Robot type		Shelf mounting		
Robot mass		1,230 kg		1,270 kg

1[rad] = 180/π[°], 1[N-m] = 1/9.8[kgf·m]

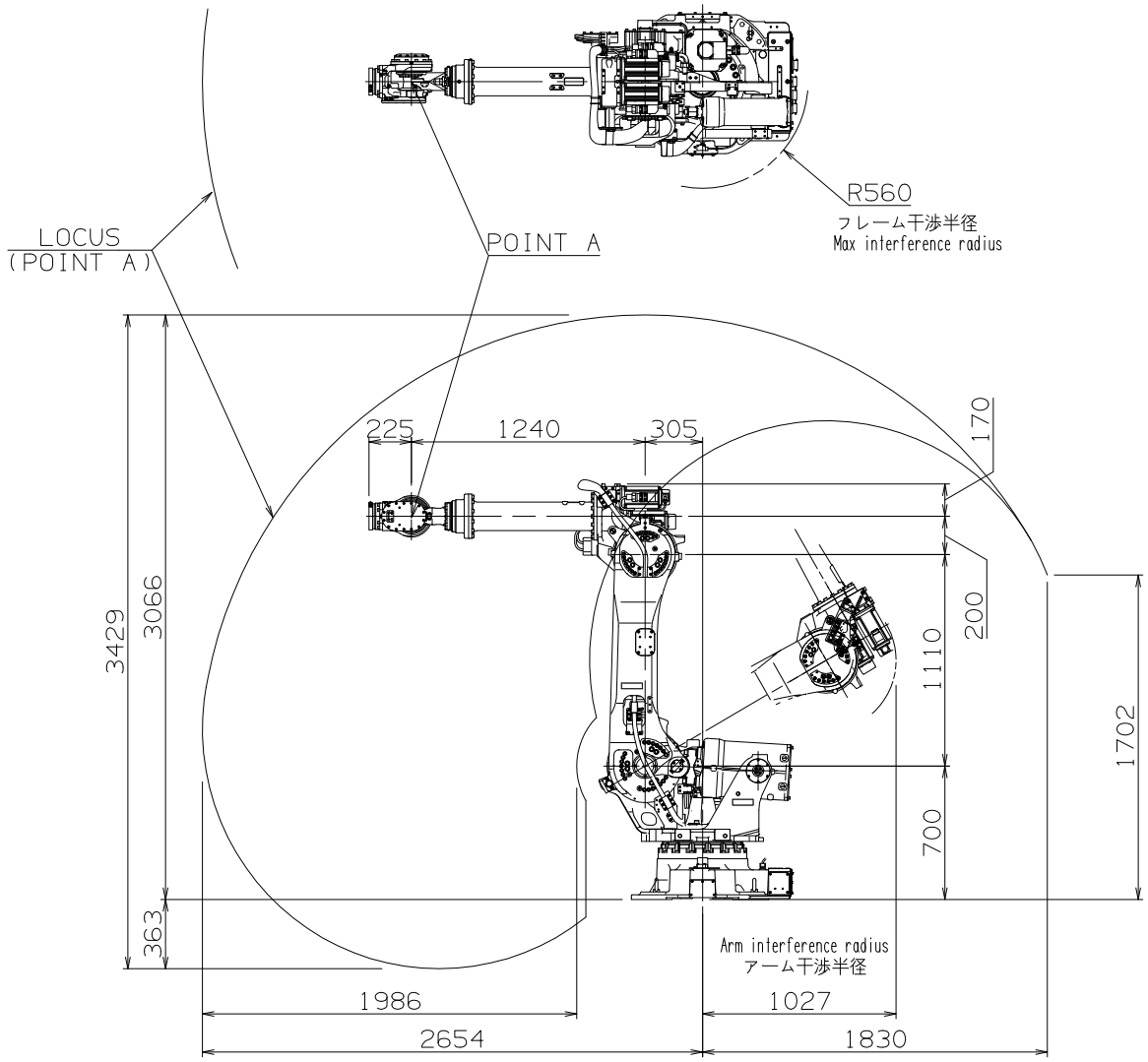
*1) Note that this load varies depending on its mounting position and the weight of wrist payload.

*2) Note that the allowable moment of inertia of wrist varies with the wrist load conditions.

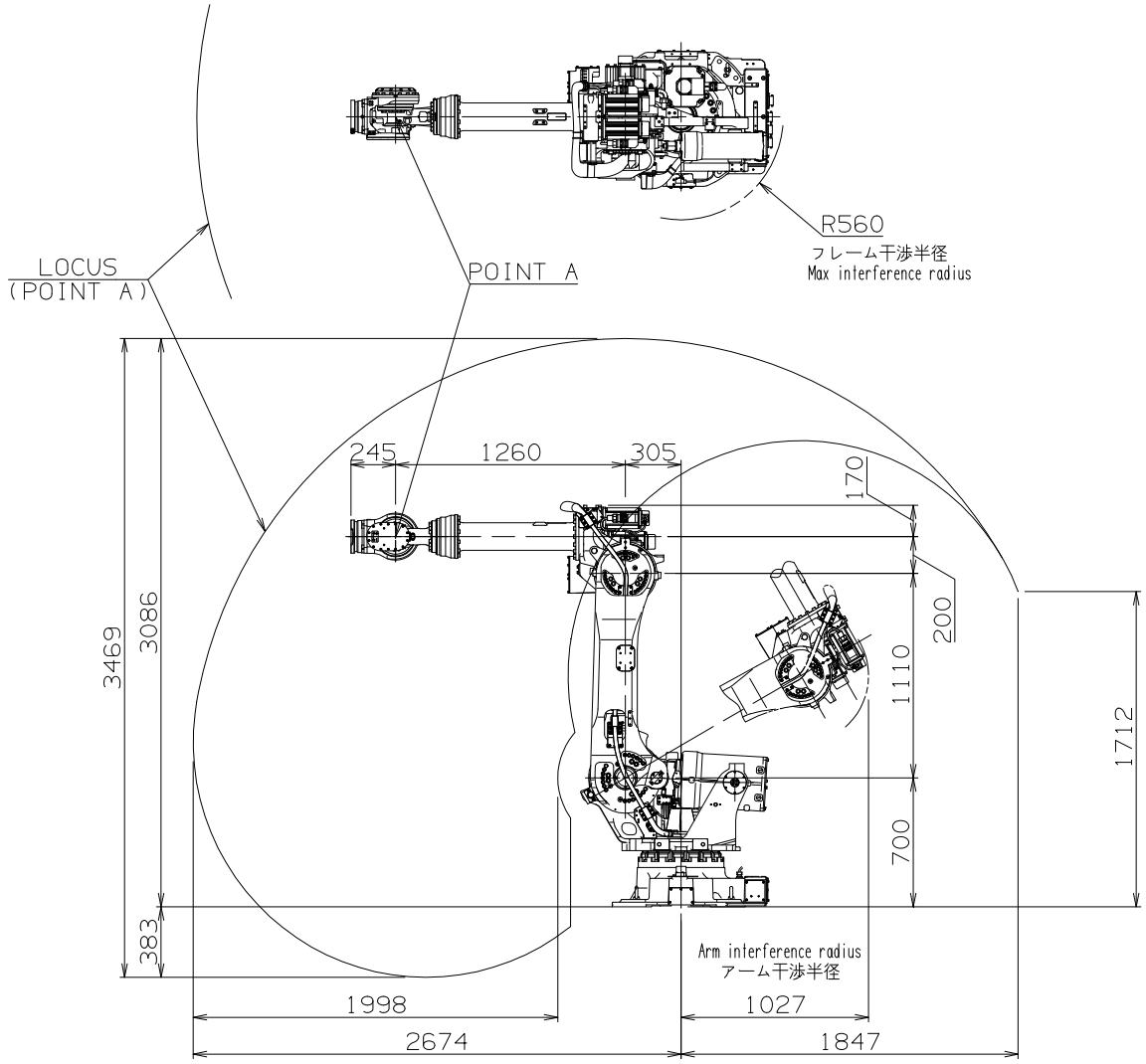
*3) Note that this value is determined under the rule of JIS B 8432.

1.3 Outline dimensions and operating area of robot

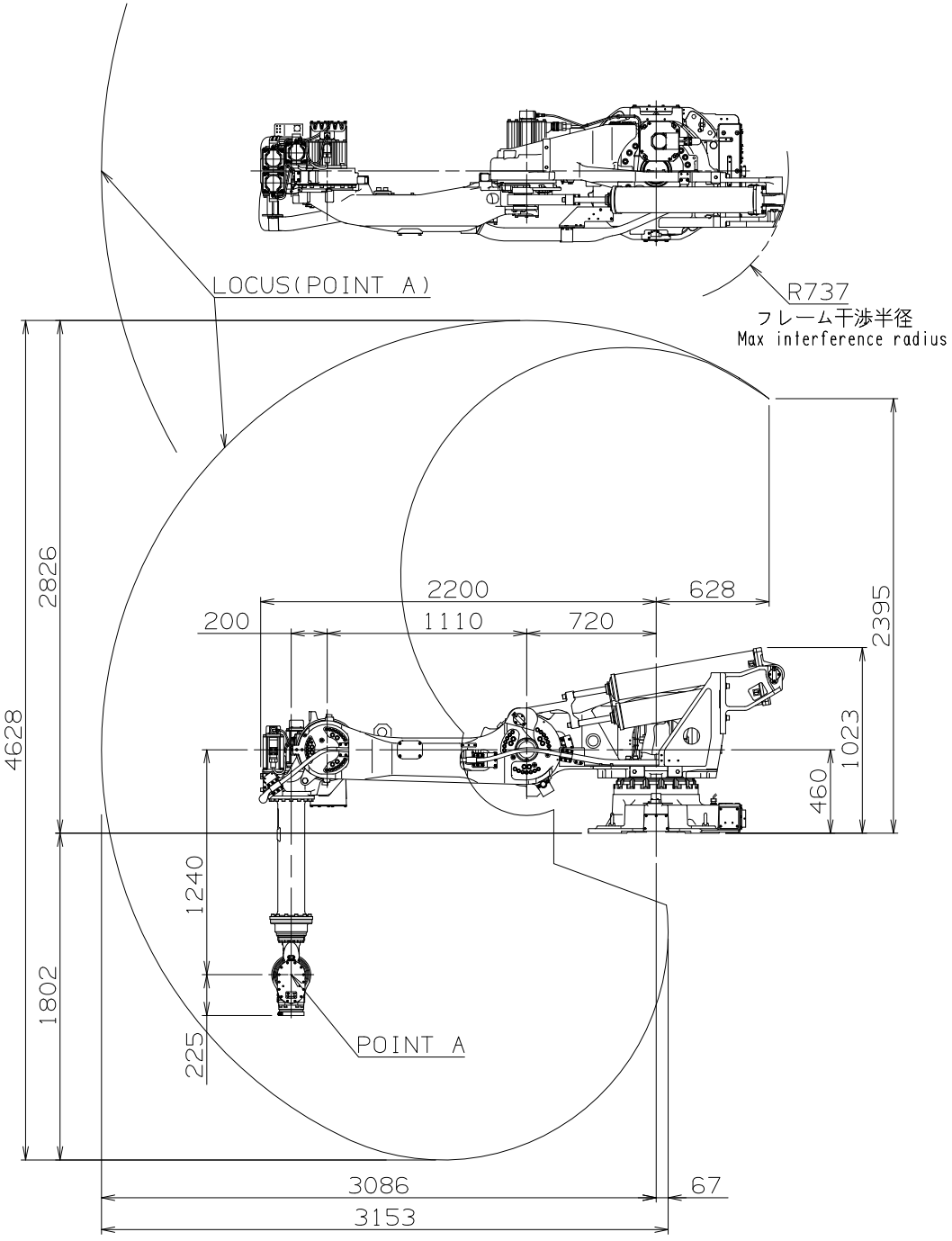
[ST133F-01] [ST166F-01]



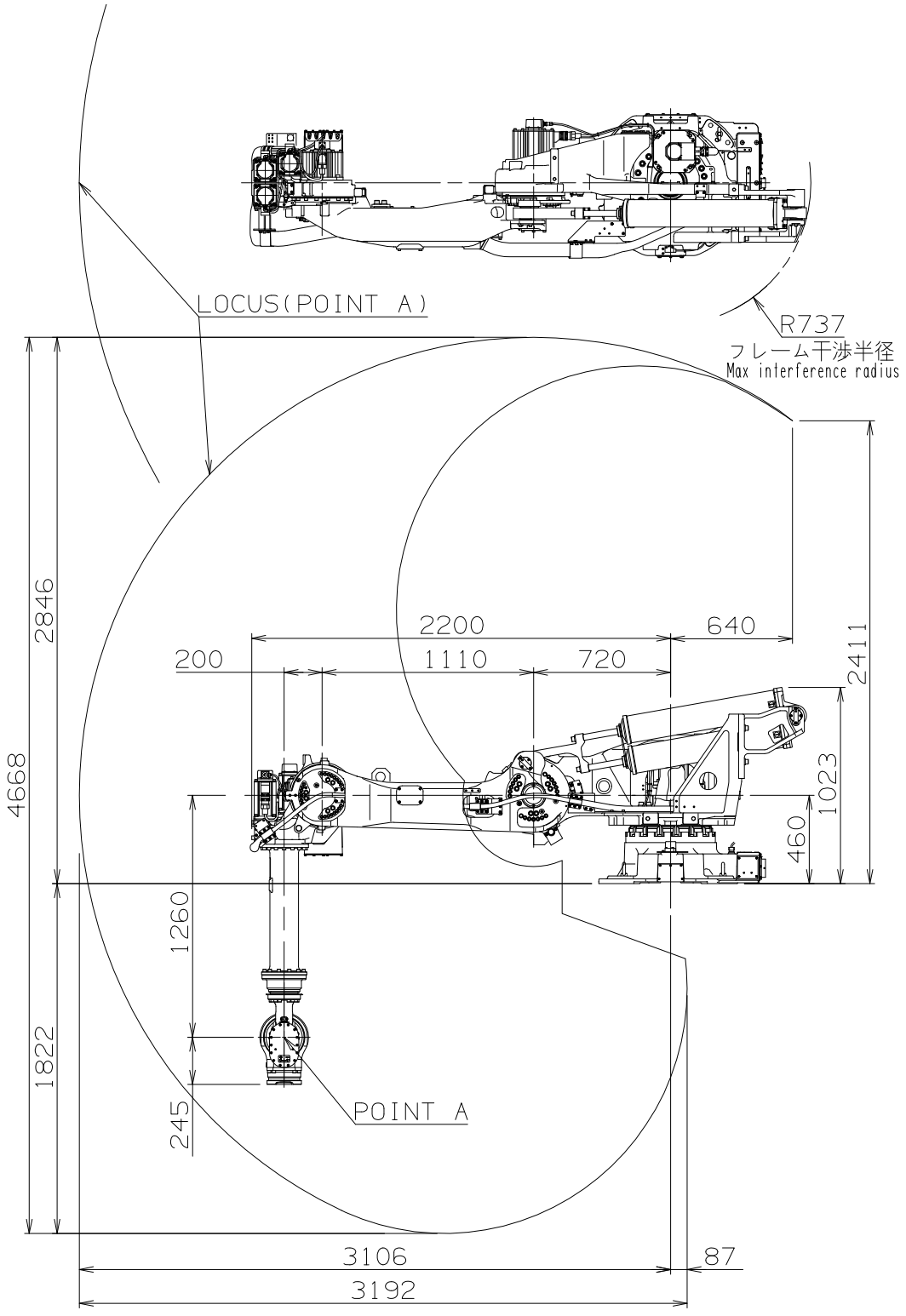
[ST210F-01]


LOCUS
(POINT A)
POINT A
R560
フレーム干渉半径
Max interference radius
245
1260
305
170
200
1110
700
1712
3469
3086
383
Arm interference radius
アーム干渉半径
1998
2674
1027
1847

[ST133TF-01] [ST166TF-01]



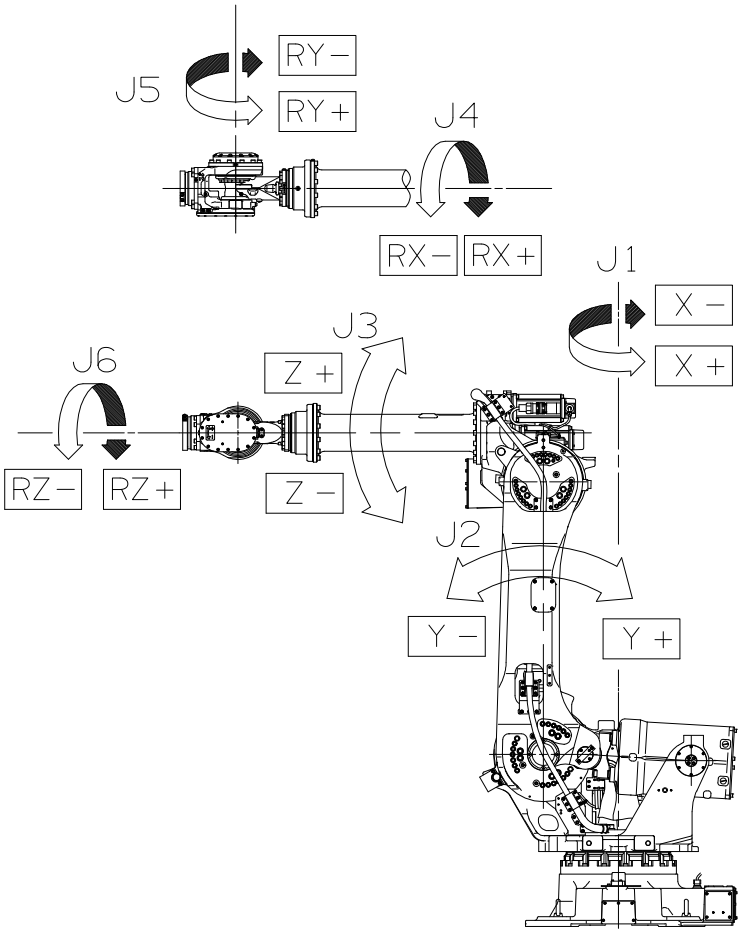
[ST210TF-01]


LOCUS(POINT A)
R737
フレーム干渉半径
Max interference radius
2846
4668
2200
640
200
1110
720
2411
1023
460
1260
1822
245
POINT A
3106
87
3192

1.4 Names of operating axes

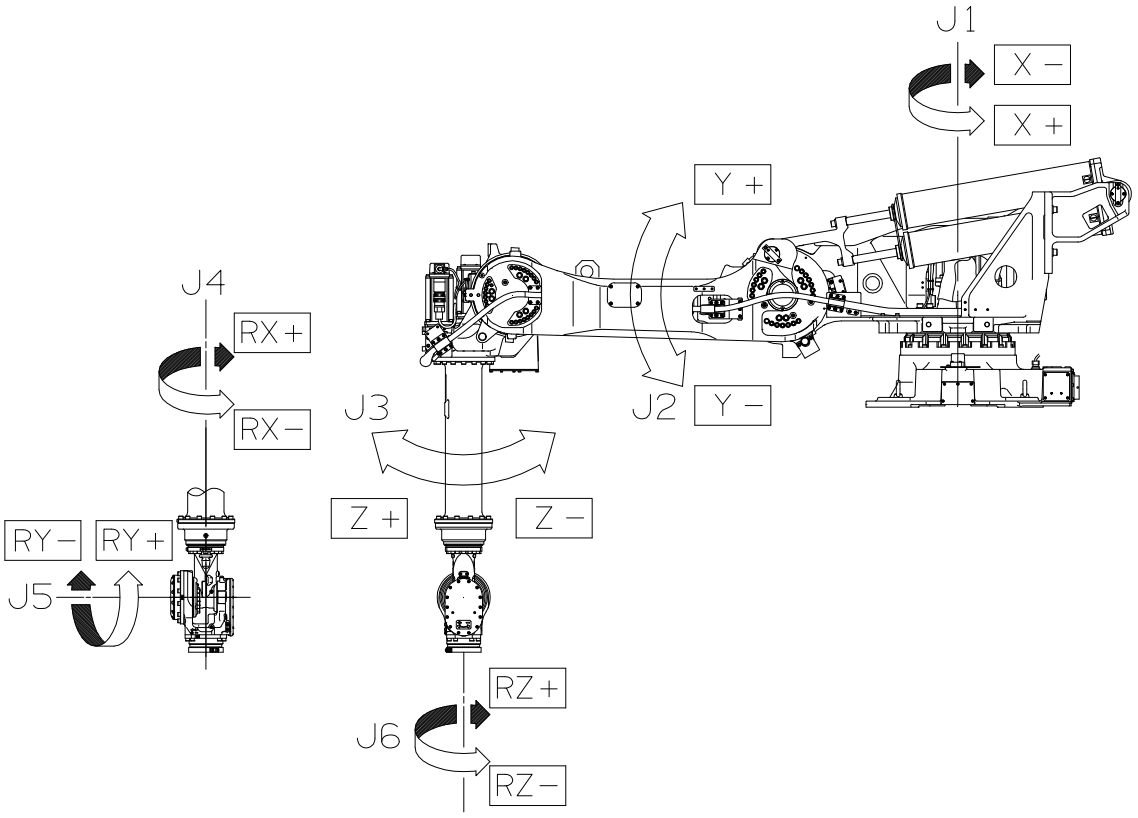
[ST133F-01] [ST166F-01] [ST210F-01]

Axis name	Operation	Teaching pendant button	
J1	Arm swivel	X-	X+
J2	Arm forward/backward	Y-	Y+
J3	Arm up/down	Z-	Z+
J4	Wrist rotation 2	RX-	RX+
J5	Wrist bending	RY-	RY+
J6	Wrist rotation 1	RZ-	RZ+



[ST133TF-01] [ST166TF-01] [ST210TF-01]

Axis name	Operation	Teach pendant button	
J1	Arm swivel	X-	X+
J2	Arm up/down	Y-	Y+
J3	Arm forward/backward	Z-	Z+
J4	Wrist rotation 2	RX-	RX+
J5	Wrist bending	RY-	RY+
J6	Wrist rotation 1	RZ-	RZ+



1.5 Details of wrist mounting section

For the end effecter fixing bolts, use the mounting P.C.D. shown in the following figures.
Besides the mounting P.C.D. shown in the following figures, different P.C.D. (option) is available. For details, contact our Service Division.

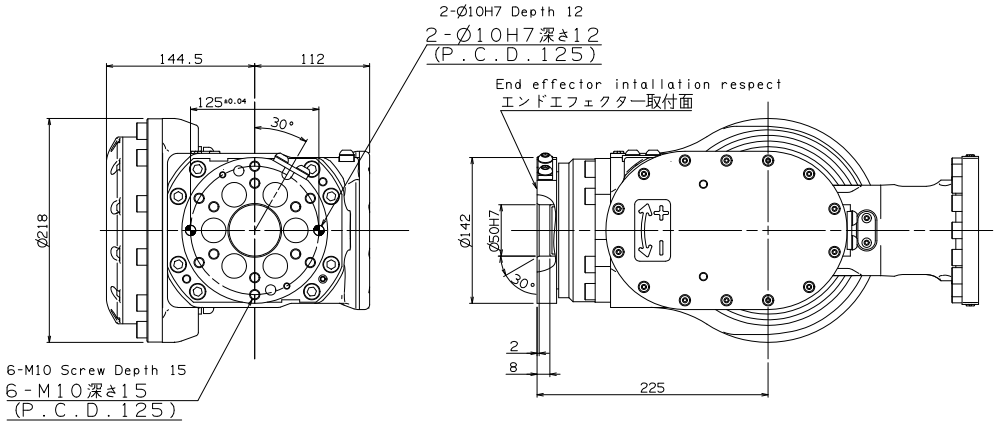
CAUTION

Be sure to screw the M10 end effecter fixing bolts in the wrist not deeper than the screw depth in the mounting face. Screwing the bolts deeper than the screw depth may damage the wrist.

[ST133F-01] [ST166F-01] [ST133TF-01] [ST166TF-01]

CAUTION

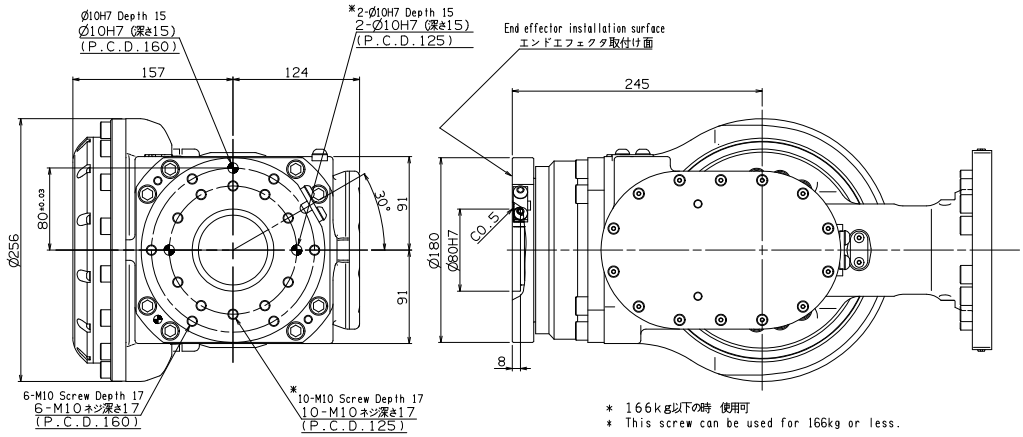
Be sure to use P.C.D.125 or P.C.D.160 when the weight of end effecter is 100kg or higher. (But if the stiffness of attachment bolt was considered inside the end effecter, above size is unnecessary.)



[ST210F-01] [ST210TF-01]

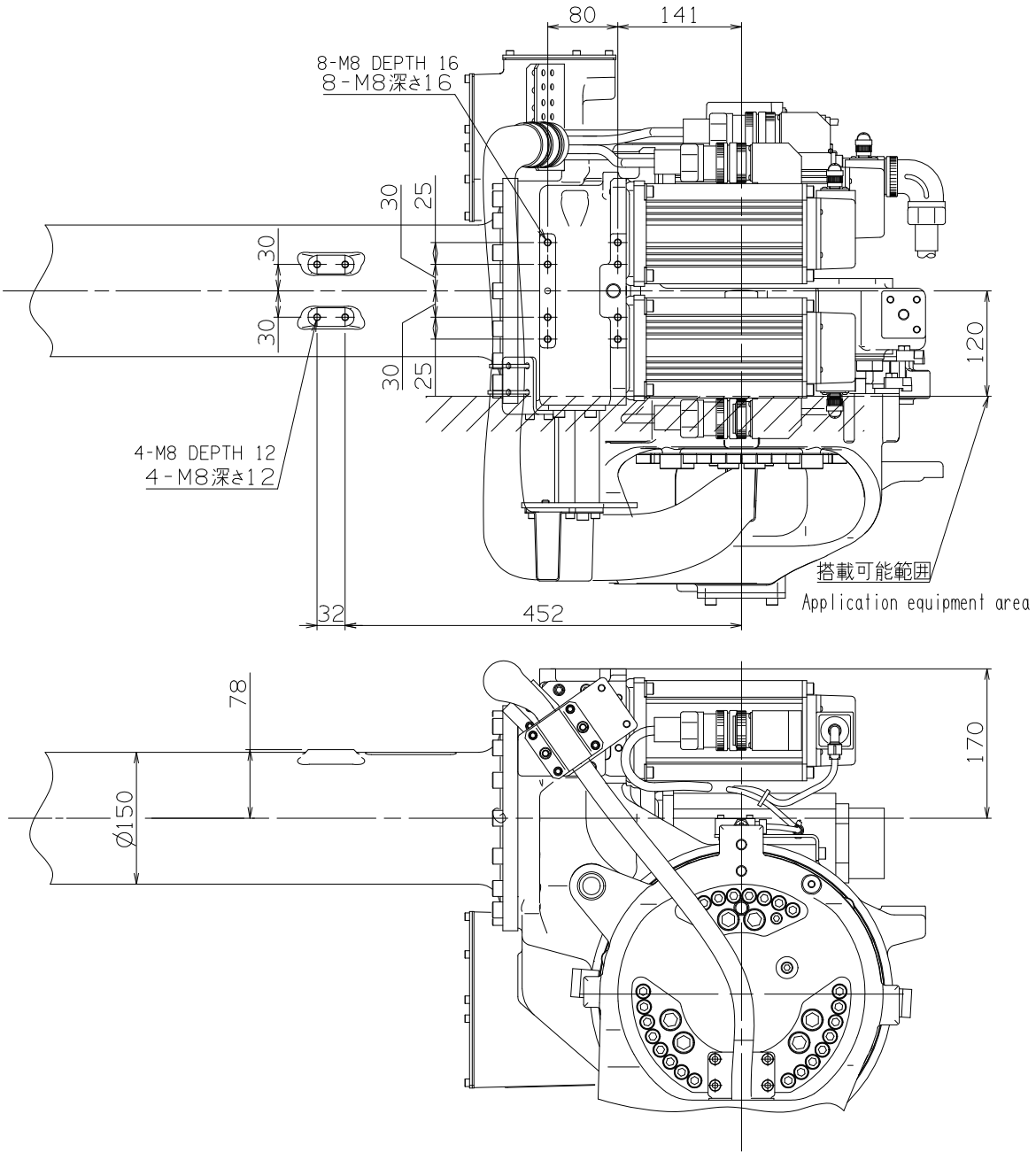
CAUTION

Be sure to use P.C.D.160 when the weight of end effecter is 166kg or higher.



1.6 Details of upper part of forearm

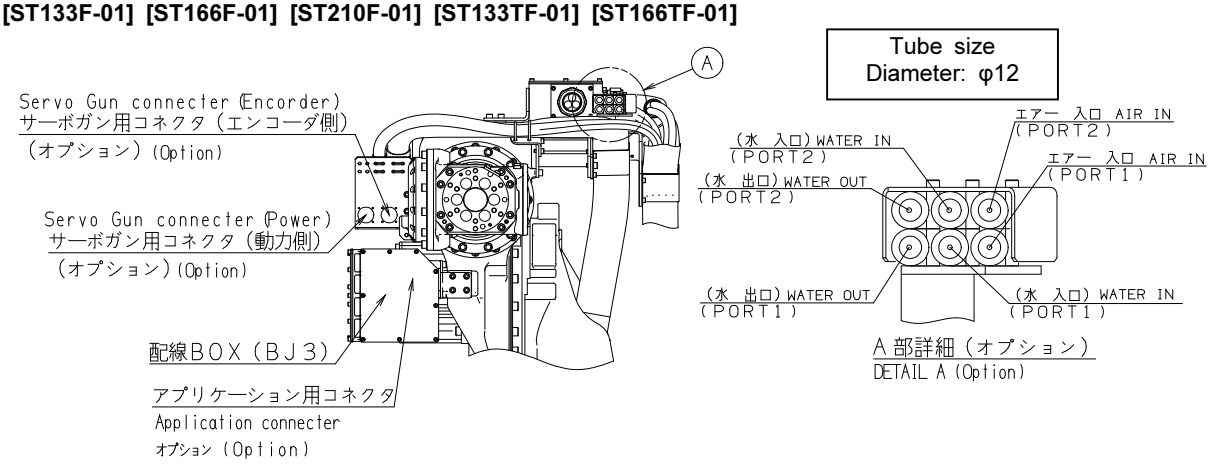
[ST133F-01] [ST166F-01] [ST210F-01] [ST133TF-01] [ST166TF-01] [ST210TF-01]



1.7 Wiring and piping diagram for application

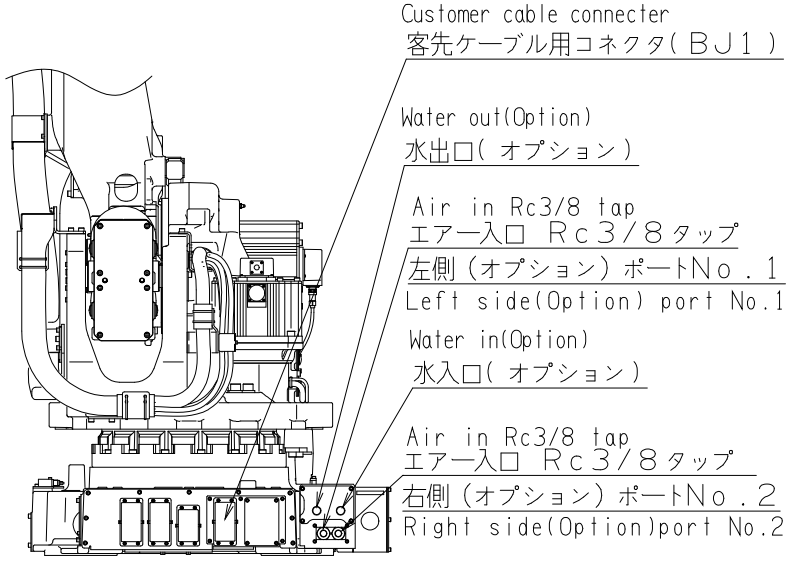
Use air pressure not more than 0.49MPa.

Upper part of forearm - Wiring and piping diagram for application
[ST133F-01] [ST166F-01] [ST210F-01] [ST133TF-01] [ST166TF-01]



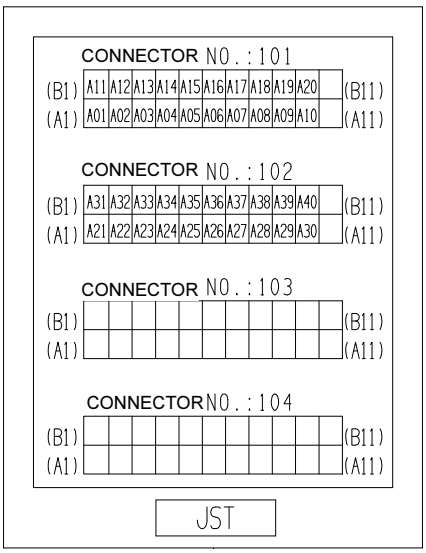
(NOTE) In the wiring box, there are application connectors shown in the next page

Base frame block - Wiring and piping diagram for application
[ST133F-01] [ST166F-01] [ST210F-01] [ST133TF-01] [ST166TF-01] [ST210TF-01]



Details of connectors for application

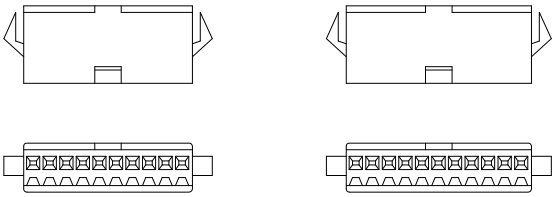
(1) BJ1-side (Connectors) (Option)



Connectors for application cables
- Wire-side shell : JFM-WSA-4-A (JST)
  JFM-WSA-4-C (JST)
- Guide plate A kit : JFM-GPAK-4 (JST)
- Receptacle housing : JFM2FDN-22V-K (JST)
- Receptacle contact
  - a SJ2F-01GF-P1.0 (JST) 0.20~0.50sq
  - b: SJ2F-01GF-P1.0 (JST) 0.30~0.75sq
- Manual crimp tool
  - a: YRS-8861
  - b: YRF-1120
- Cable diameter suitable for wire-side shell
  - JFM-WSA-4-A : φ26.2~φ28.0
  - JFM-WSA-4-C : φ15.5~φ16.5

Specification of Application wires
- Rated voltage maximum AC/DC 115 V
- Rated ampere maximum 1 A

(2) BJ3-side (Relay connectors) (Option)



<u>Connector models (CN61,CN63)</u>
Housing SMP-10V-BC (JST)
<u>User-side connectors</u>
Housing SMR-10V-B (JST)
Contact SYM-001T-P0.6
(Suitable cable: AWG#22~28)
Manual crimp tool: YRS-121

<u>Connector models (CN62,CN64)</u>
Housing SMP-11V-BC (JST)
<u>User-side connectors</u>
Housing SMR-11V-B (JST)
Contact SYM-001T-P0.6
(Suitable cable: AWG#22~28)
Manual crimp tool: YRS-121

CN61

1	2	3	4	5	6	7	8	9	10
A01	A02	A03	A04	A05	A06	A07	A08	A09	A10

CN62

1	2	3	4	5	6	7	8	9	10	11
A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	ECE

CN63

1	2	3	4	5	6	7	8	9	10
A21	A22	A23	A24	A25	A26	A27	A28	A29	A30

CN64

1	2	3	4	5	6	7	8	9	10	11
A31	A32	A33	A34	A35	A36	A37	A38	A39	A40	ECE

Notes) In case of spot welding specification, CN61 and CN62 connectors are wired through to the wrist flange for the application cable, and CN61 and CN62 connectors do not locate inside the BJ3 box.

1.8 Operating range adjustment

WARNING

With stoppers dismounted, do not operate the robot. Doing so may result in damage to the peripheral equipment and the like, or death or serious injury.

WARNING

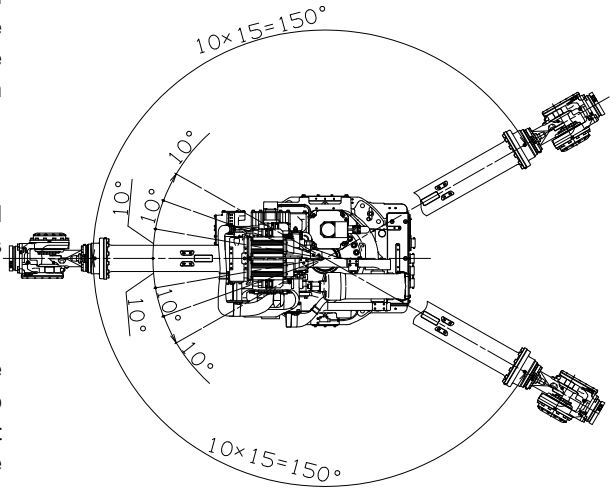
When changing the mechanical stopper's position, change the position of the over-travel limit switch (option) and the setting of the software limit also. If not changed, the mechanical stopper may be damaged. And, the mechanical stopper should be installed outside of the motion range defined by the software limit function and the over-travel limit switch (option).

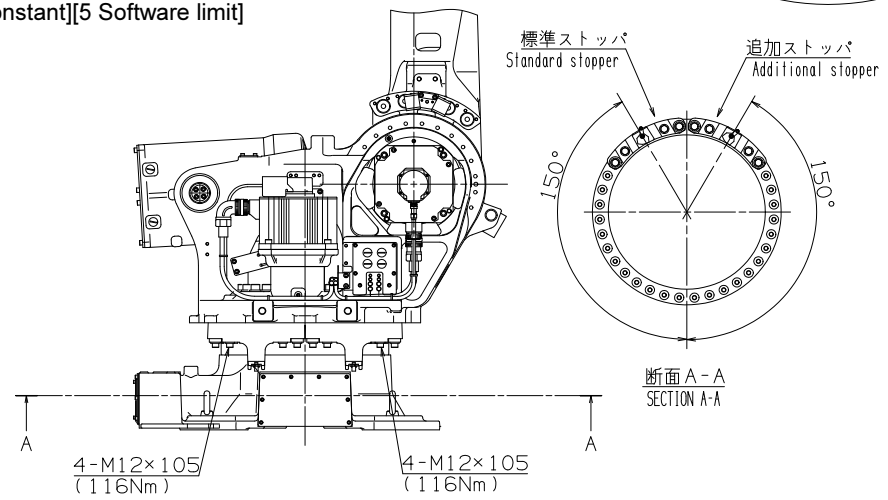
1.8.1 J1-axis adjustable stopper (option)

Mounting the standard stopper and the additional stopper (option) of the same shape as that of the standard stopper makes it possible to adjust the operating angle of the J1 axis in steps of 10°. In this case, a maximum operating range of the J1 axis comes to ±150°.

(1) Dismount the stopper from the standard mounting position, and then mount the stoppers according to an angle to be adjusted. (Fixing bolt: M12 × 105 × 4 bolts)

(2) Adjust the software limit according to the angle adjusted. For the software limit adjustment, refer to information in "Software limit" in the teach pendant electronic manual [Constant settings][3 Machine constant][5 Software limit]





The end of a mechanical stopper is provided in a position exceeding the software limit by 3°.

1.8.2 J2-axis adjustable stopper (option)

WARNING

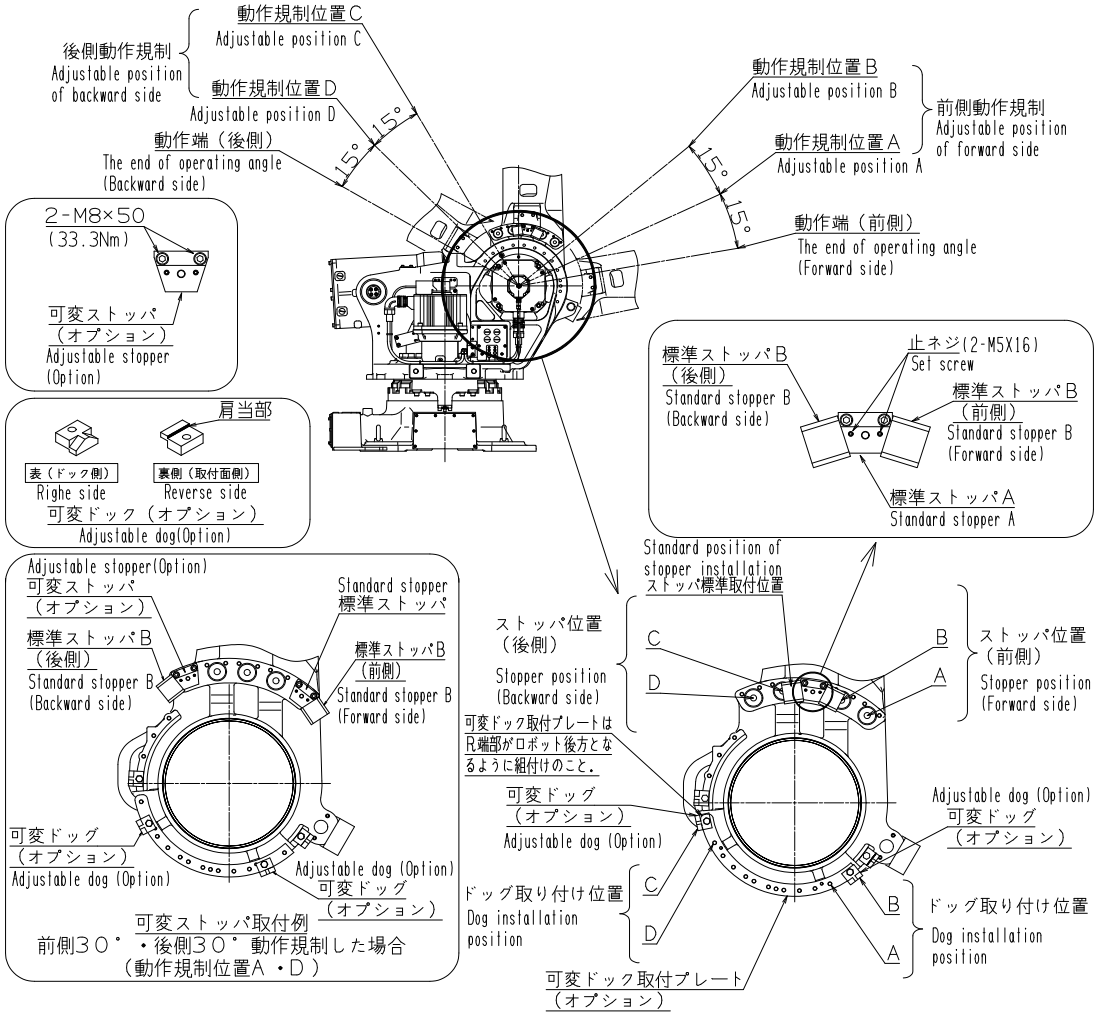
NEVER mount a stopper only on the front (lower) side or the rear (upper) side.

Mounting the standard stopper and the adjustable stopper (option) of the same shape as that of the standard stopper makes it possible to adjust the operating angle of the J2 axis.

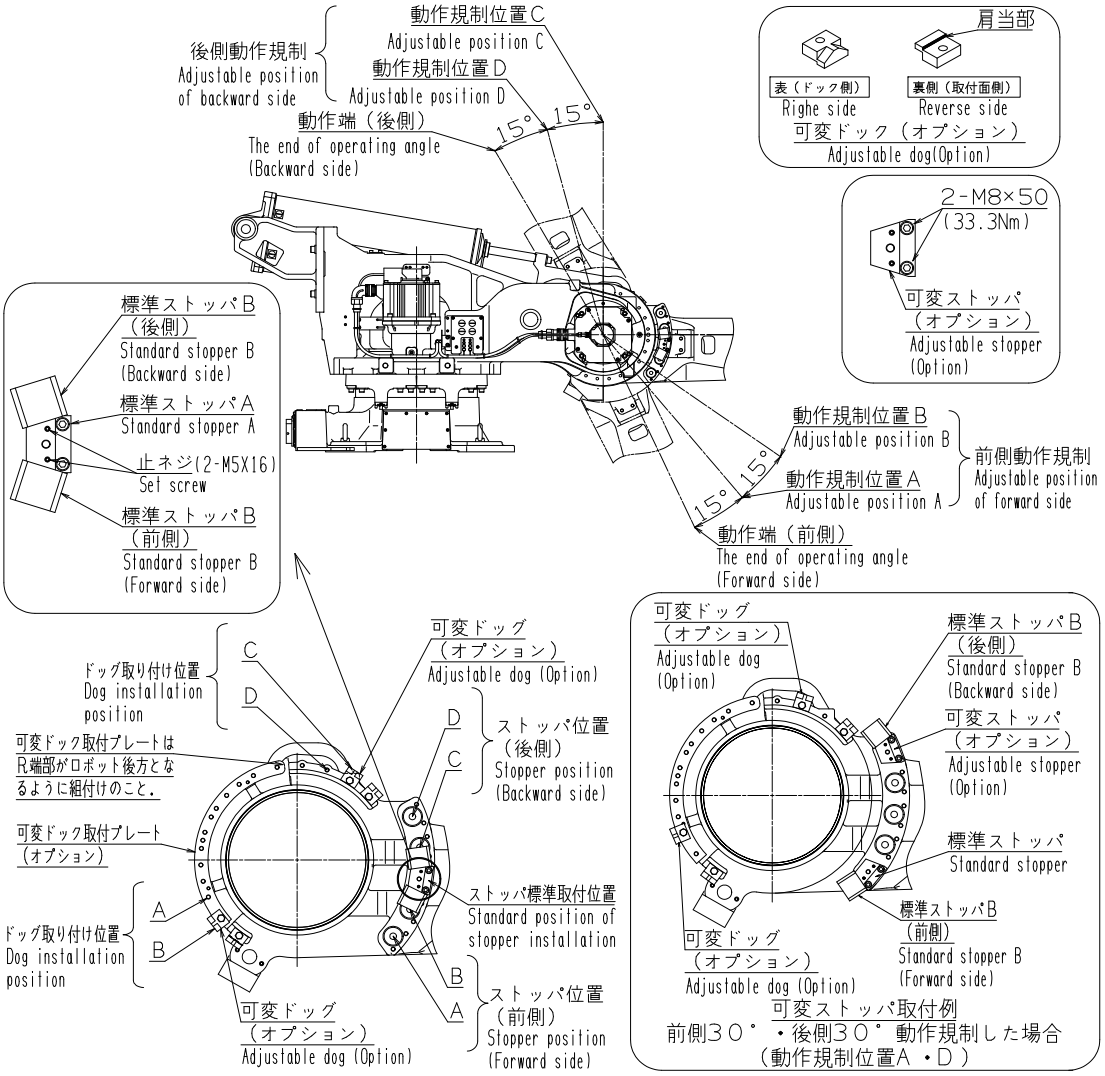
For adjustable positions, refer to the following figures.

(1) Unscrew the setscrews from the standard stopper B on the adjustable side, and then dismount the stopper B from the standard stopper A.
(2) Mount the adjustable stopper (option) at an angle to be adjusted. (Fixing bolt: M8 × 50 × 2 bolts)
(3) Mount the standard stopper B to the adjustable stopper, and then fix them with the setscrews.
(4) Mount the adjustable dog (option) of the limit switch according to the adjusted angle.
(5) Change the software limit according to the adjusted angle.
For the software limit adjustment, refer to information in “Software limit” in the teach pendant electronic manual [Constant settings][3 Machine constant][5 Software limit]

[ST133F-01][ST166F-01][ST210F-01]



[ST133TF-01][ST166TF-01][ST210TF-01]



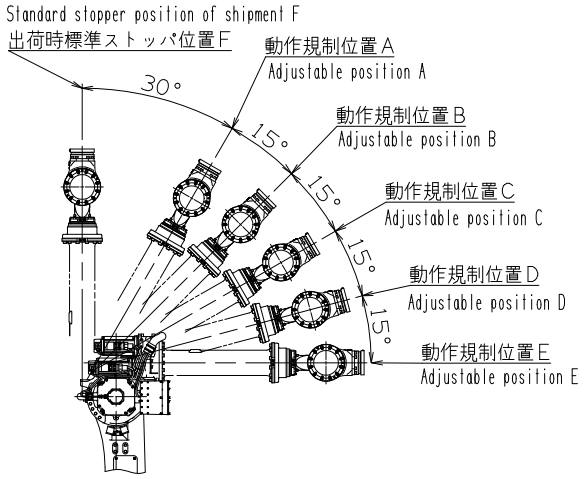
1.8.3 J3-axis adjustable stopper (option)

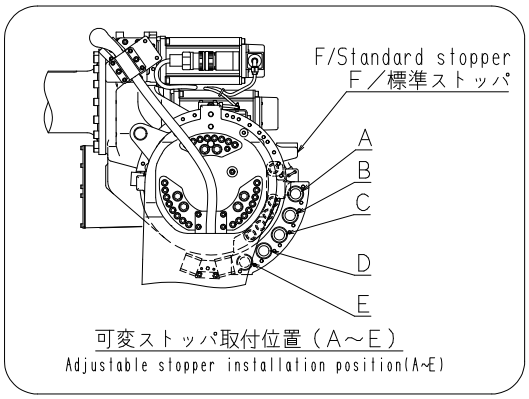
Mounting the standard stopper and the adjustable stopper (option) of the same shape as that of the standard stopper makes it possible to adjust the upward movement of the J3 axis. For adjustable positions, refer to the following figure.

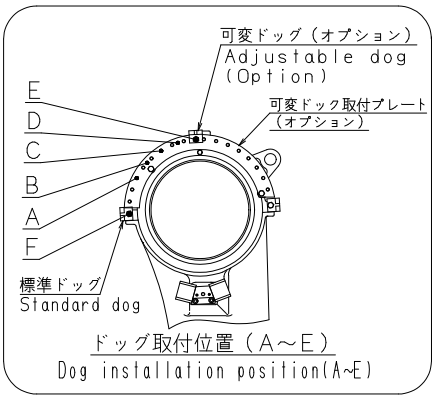
(1) Dismount the standard stopper B from the standard stopper A and mount the standard stopper B to the adjustable stopper (option).

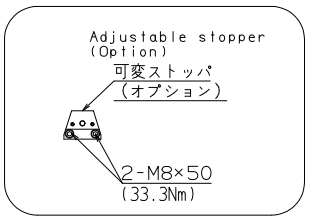
(2) Mount the adjustable stopper (option) at an angle to be adjusted.
(Fixing bolt: M8 × 50 × 2 bolts)

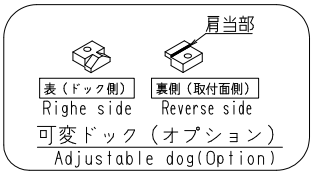
(3) Mount the adjustable dog (option) of the limit switch according to the adjusted angle.
Change the software limit according to the adjusted angle.
For the software limit adjustment, refer to information in “Software limit” in the teach pendant electronic manual [Constant settings][3 Machine constant][5 Software limit]

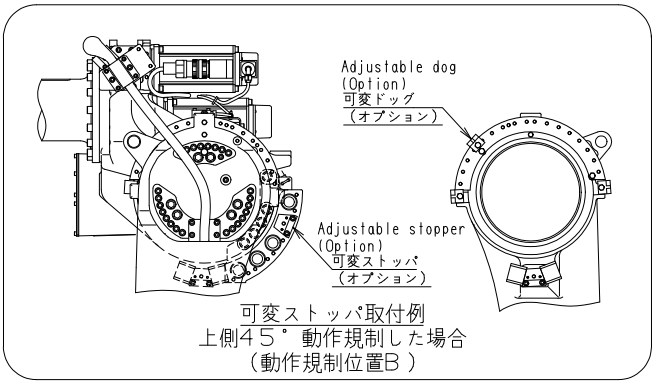










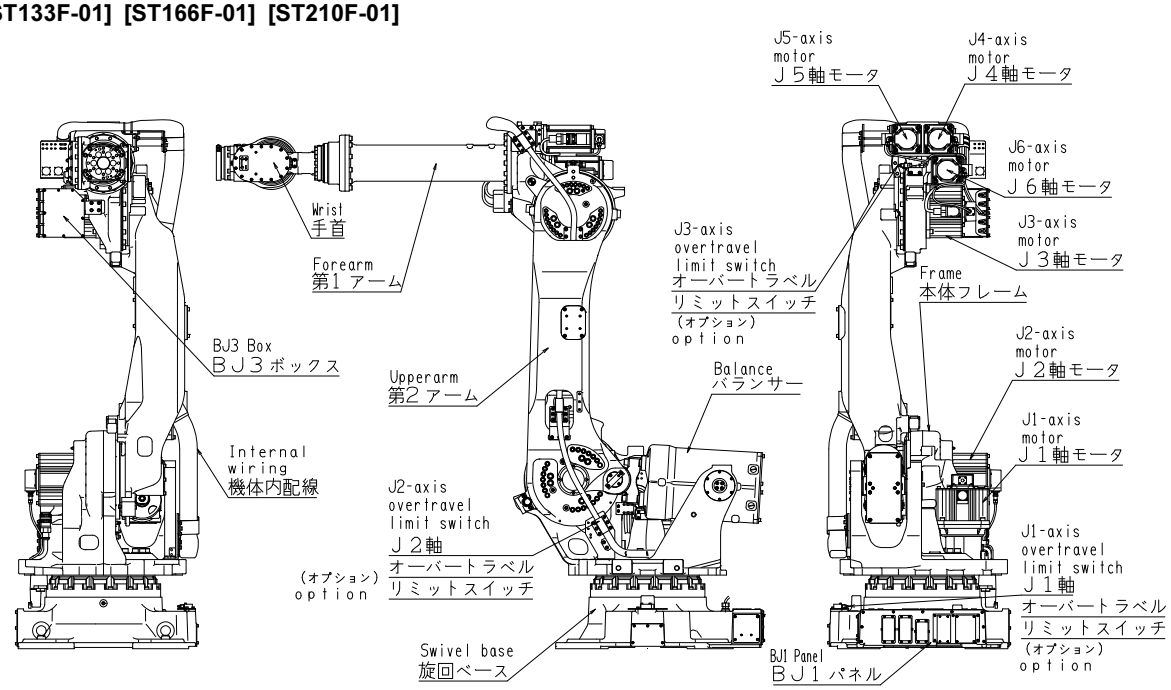


NOTE

Chapter 2 Precautions for handling

2.1 Names of robot components

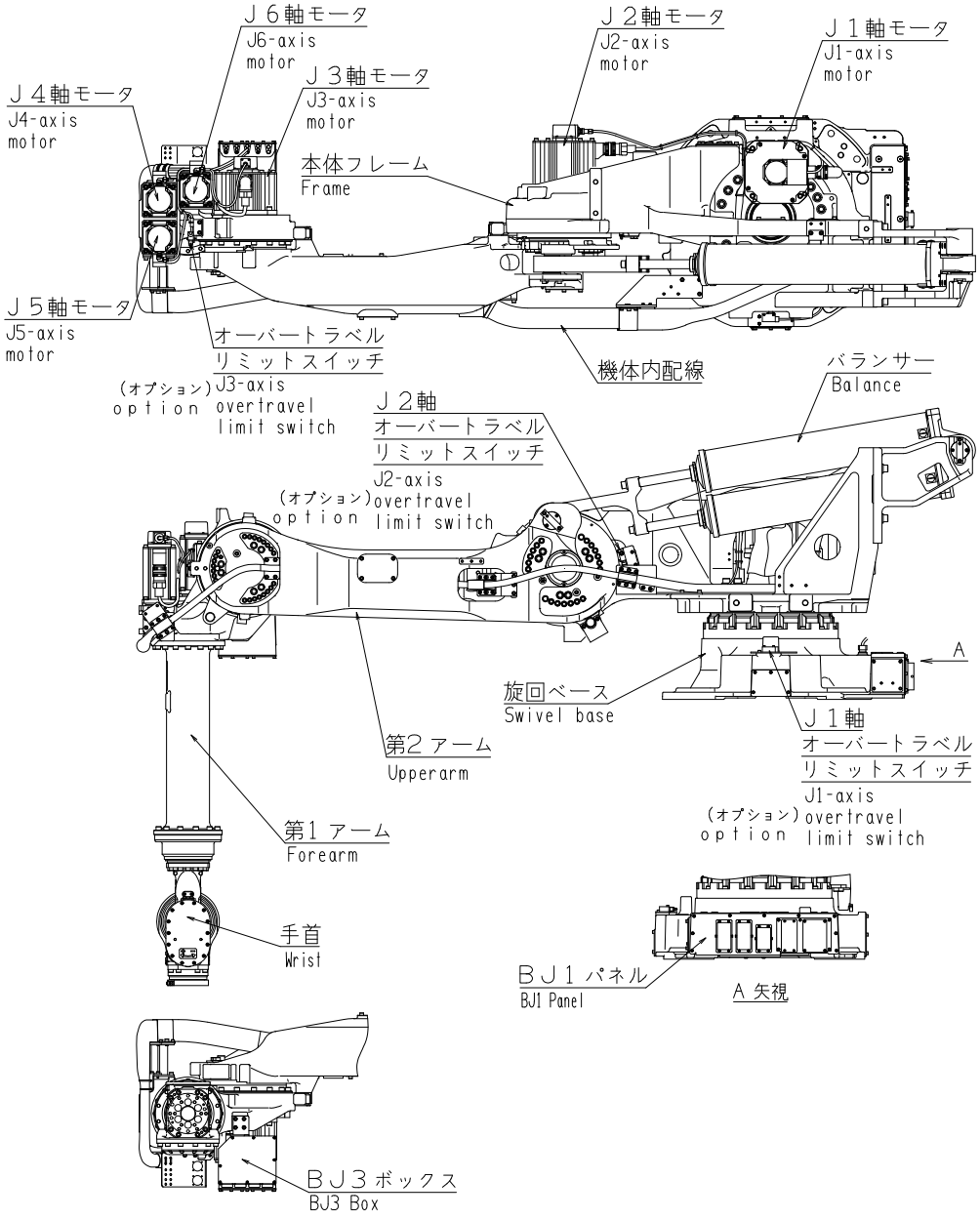
[ST133F-01] [ST166F-01] [ST210F-01]



CAUTION

The over travel limit switches are option.

[ST133TF-01] [ST166TF-01] [ST210TF-01]

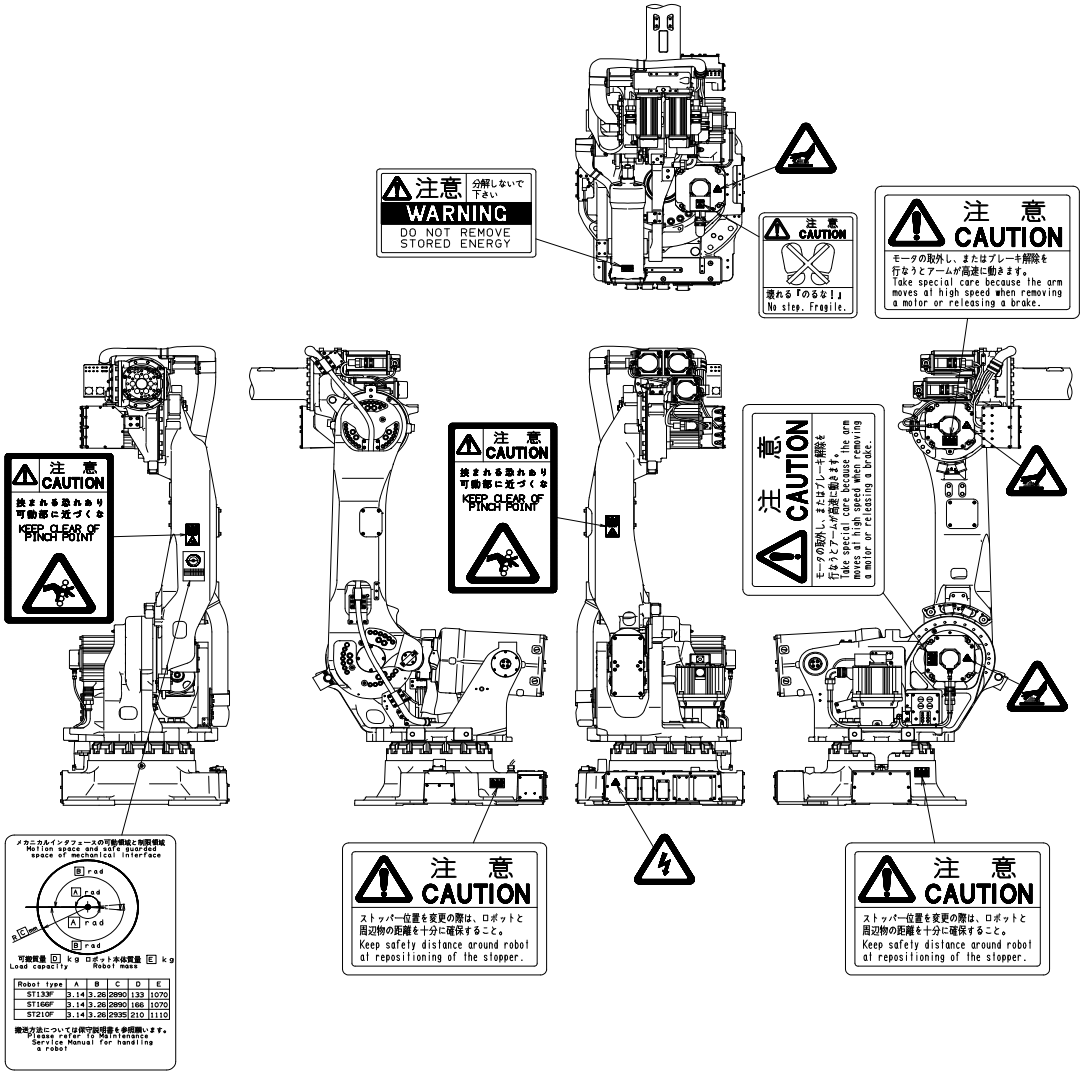


CAUTION

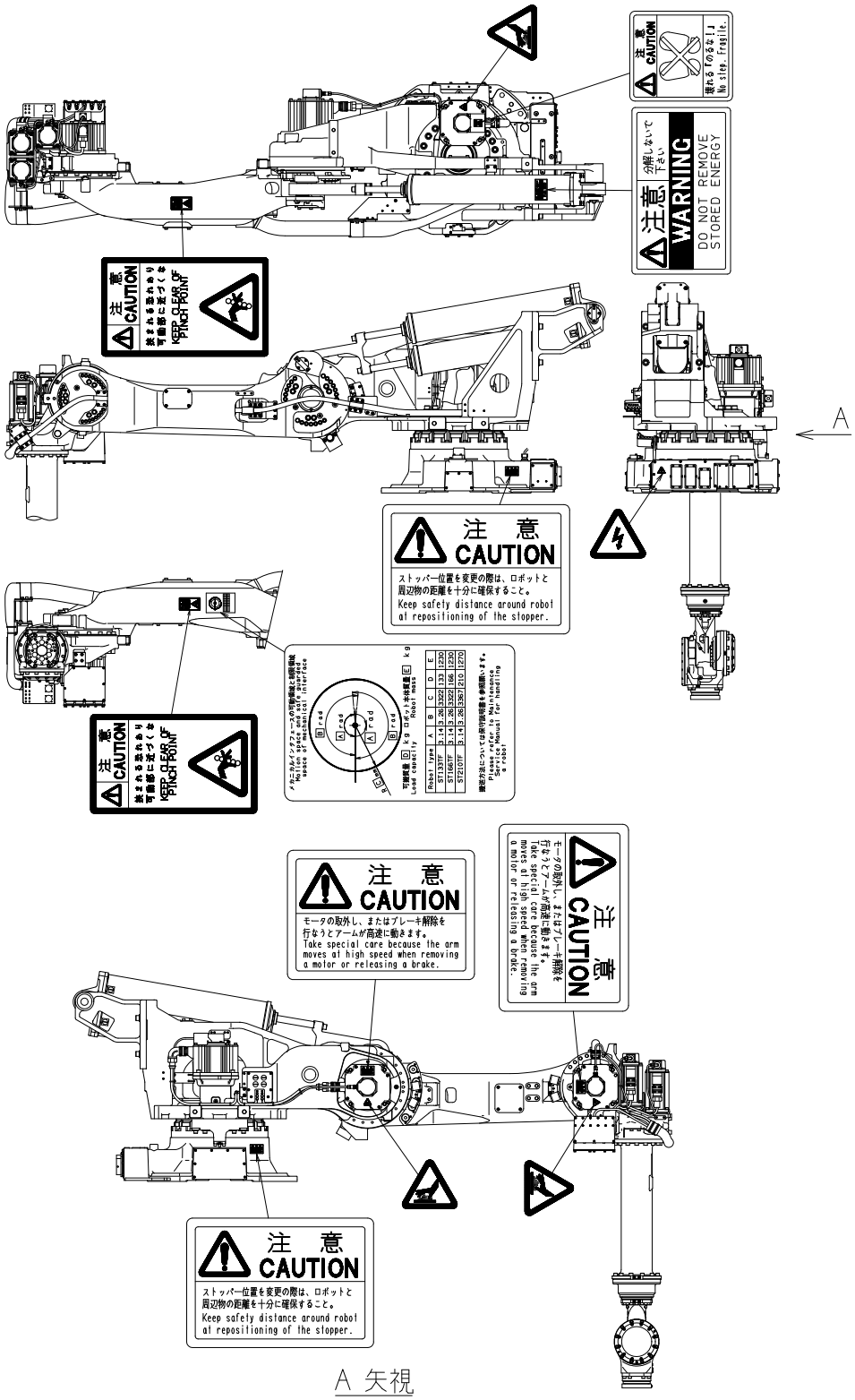
The over travel limit switches are option.

2.2 Hazardous points

[ST133F-01] [ST166F-01] [ST210F-01]



[ST133TF-01] [ST166TF-01] [ST210TF-01]



2.3 Transport procedure

Safety measures against transport

The following section describes precautions for transporting the robot. Fully understand the precautions for safe transport work.

WARNING

The robot must be transported by personnel who have licenses required for slinging work, crane operation, forklift truck operation, and others. The weight of the robot and controller is listed in the Operating Manual and the Maintenance Manual. Check for the weight, and then handle them according to procedures suitable for the weight.

WARNING

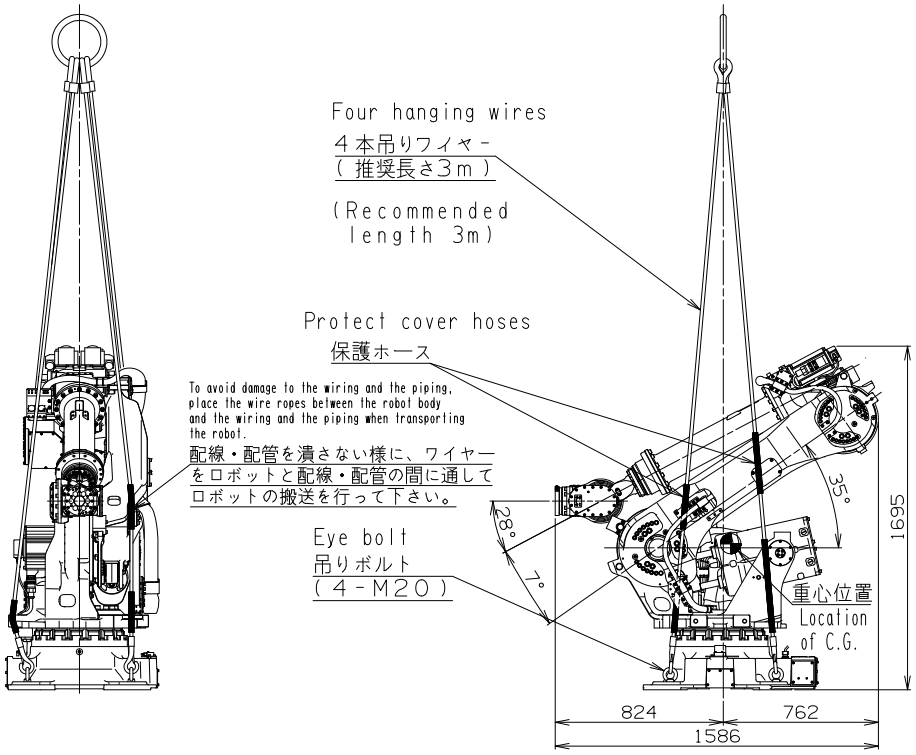
To lift the robot or the controller, follow the procedures specified in the Maintenance Manual.
Following any procedures other than those specified will cause the robot to topple over or drop during transport, thus resulting in accidents.

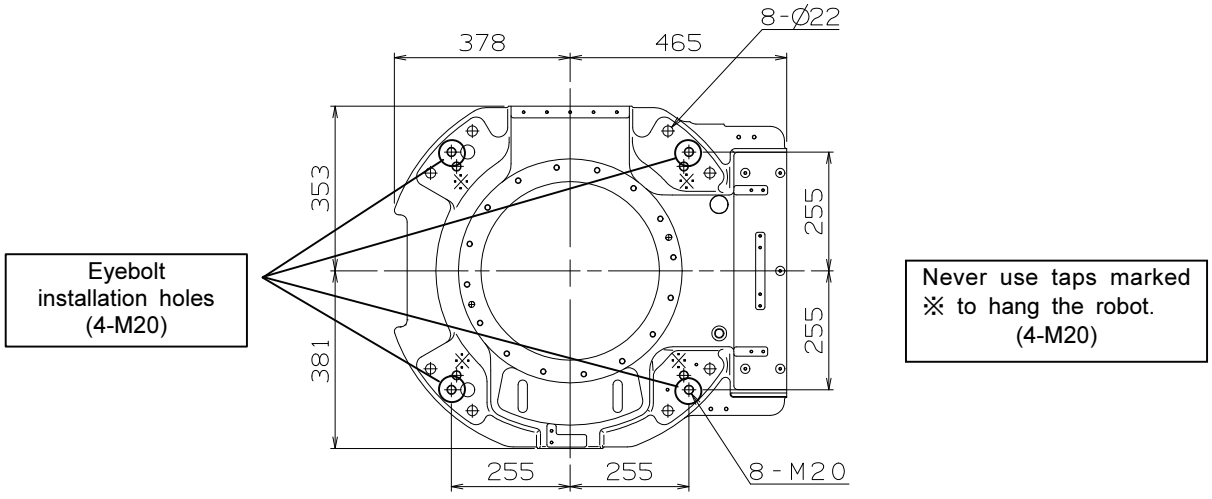
CAUTION

During transport or installation work of the robot, pay utmost care not to cause damage to wirings.
Furthermore, after installing the robot, take protective measures such as using protective guards so that the wirings will not be damaged by workers or other persons, or forklift trucks or else.

[ST133F-01] [ST166F-01] [ST210F-01]

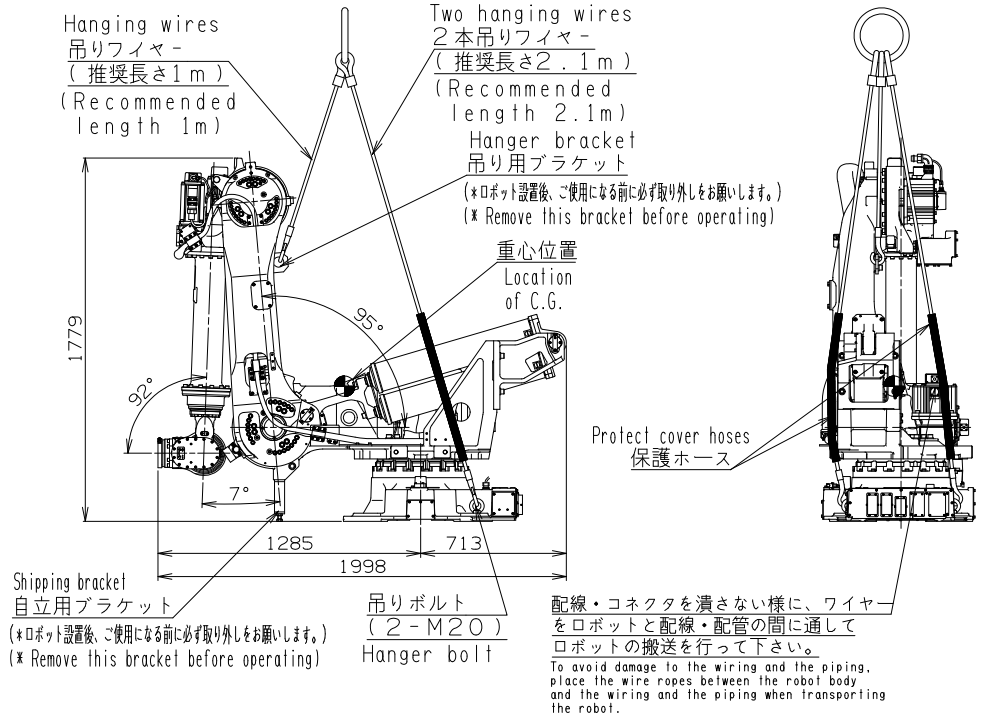
To transport the robot, make it a rule to use a crane.
First, put the robot into the configuration shown in Fig. 2.2-1 below and mount the four M20 hanger bolts to the robot frame. Then, be sure to lift the robot using four hanging wires.
For this purpose, it is recommended to use hanging wires of 3 m in length and protect areas that contact the robot, using rubber hoses to cover the wire ropes.
For the areas to be covered with the rubber hoses, refer to Fig. 2.2.1.

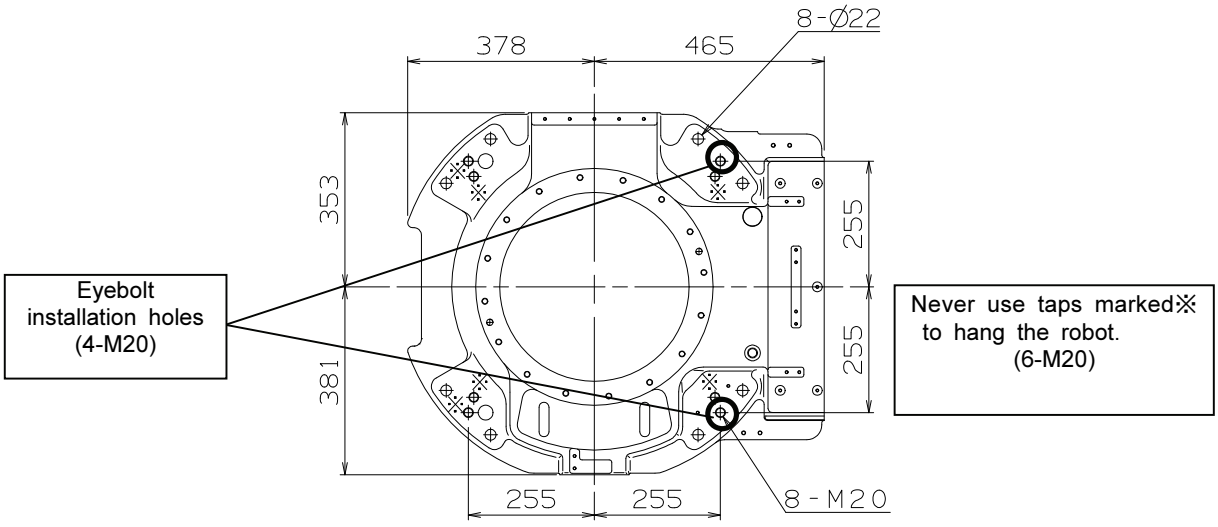




[ST133TF-01] [ST166TF-01] [ST210TF-01]

To transport the robot, make it a rule to use a crane.
First, put the robot into the configuration shown in the figure shown as below and mount the hanging bracket onto the arm, and attach two M20 hanger bolts to the robot frame (back side). Then, be sure to lift the robot using three hanging wires (For this purpose, it is recommended to use 2 hanging wires of 2.1 [m] in length and 1 hanging wire of 1.0[m] in length). And protect areas that contact the robot, using rubber hoses to cover the wire ropes.
For the areas to be covered with the rubber hoses, refer to the following figure.

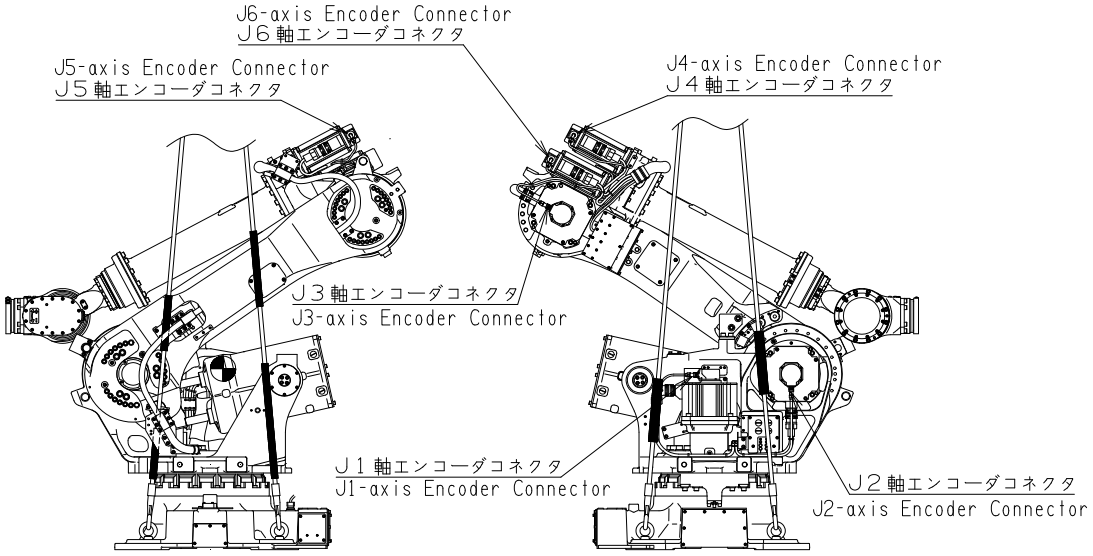




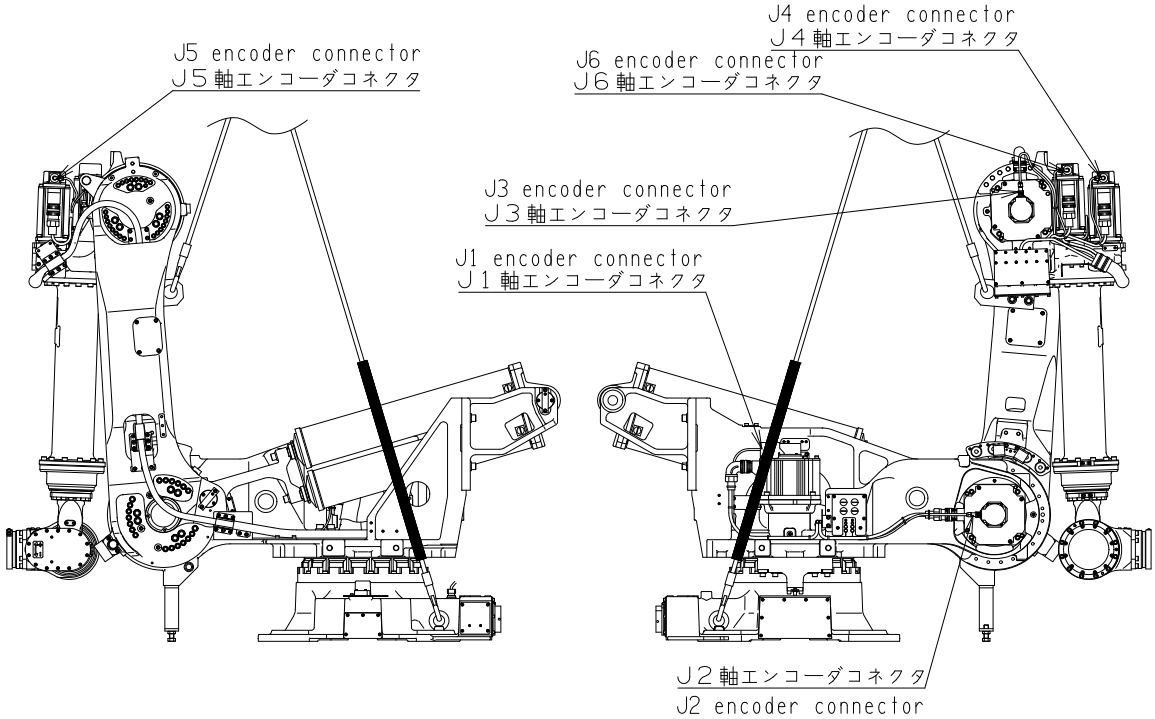
CAUTION

If hanging wires push the encoder connectors, the connectors may be broken when hanging the robot. When hanging a robot, please pay attention not to make the wires touch the encoder connectors.

[ST133F-01] [ST166F-01] [ST210F-01]



[ST133TF-01] [ST166TF-01] [ST210TF-01]



2.4 Installation procedure

The installation location and the installation procedure of the robot are critical factors to maintain robot functions. The ambient conditions of installation location not only have influence on the life of mechanical sections of the robot, but also get involved in safety issues. Consequently, strictly observe the environmental conditions shown below. Furthermore, utmost care should be exerted for the installation procedure and the foundation for the robot in order to maintain the robot performance. Strictly observe the installation procedure for the robot provided below.

Installation

To install the robot, give it first priority to thoroughly consider safety of workers and take safety measures. The following section describes precautions for this purpose.

Safety measures against entry in the robot operating area

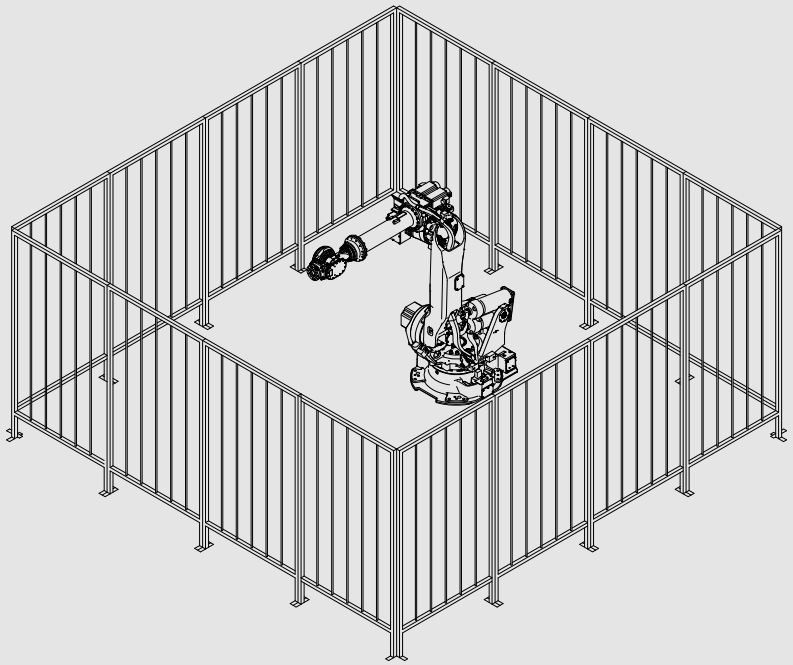
WARNING

While the robot is in operation, workers are in danger of coming in contact with the robot. To avoid that, install a **guard fence** so as to keep the worker away from the robot. Not doing so will cause the workers or other persons to accidentally enter the operating area, thus resulting in accidents.

DANGER

Guard fence

Refer to information in ISO13857: Safety of machinery – Safety distances to prevent hazard zones being reached by upper and lower limbs



Stop time and angle of J1 axis for a maximum travel

(After an emergency stop signal is output when the J1-axis maximum speed is specified)

	Floor mounting	Shelf mounting
Stop time	0.79 [sec]	1.15 [sec]
Stop angle	0.87 [rad]	1.0 [rad]

WARNING

The guard fence must have construction by which no one can easily get over or move the guard fence.
A low guard fence will allow anyone to get over it, thus inducing a hazardous situation.

WARNING

Provide an access door for the guard fence that must be equipped with a **safety plug** and designed not to open unless the safety plug is unplugged. The safety plug makes it possible to detect the entry of a person in the guard fence via a signal output from the safety plug.

WARNING

Design the system so that **low-speed playback mode** will become functional in order to operate the robot with the safety plug unplugged. If the robot is operated at a high speed under the said condition, no one can escape from the robot, thus resulting in accidents.
(The controller has an input signal to select low-speed playback mode.)

WARNING

Mount **Emergency Stop buttons** for the robot **in locations where workers are able to immediately press them**. If the workers are unable to immediately press the switch, accidents may result.
(The controller has an external input for the emergency stop function.)

WARNING

If no guard fence is installed, mount **photoelectronic switches and/or mat switches, etc.** at all entrances to the robot operating area to use them in place of the safety plug. These switches make it possible to automatically stop the robot when anyone enters the guard fence.

WARNING

Coat the floor of the hazardous area (the robot operating area) **with color paint** to facilitate discrimination of the hazardous area.

Safety measures against the robot and peripheral equipment

WARNING

In order to connect the primary power supply to the controller and the peripheral equipment, check to be sure that the power on the supply side is turned OFF. Otherwise it will create a hazardous situation resulting in electric shocks since high voltages such as 100VAC, 200VAC, or 400VAC are applied.

WARNING

Do not install the operation part and the adjustment part in the robot operating area, such as locations in which a person can get caught in the robot.
Install the robot control panel, interlock panel, and all other operation panels so that they can be operated **outside the guard fence**.

WARNING

To install an operation stand, mount an **Emergency Stop button on the operation stand**. If any abnormality occurs while the robot is being operated by the use of the operation stand, the robot will be able to make an emergency stop through pressing this switch.

WARNING

Do not route wirings, piping, and the like among the robot, control panel, interlock panel, and others in such a manner that workers will stub their toes over them or forklift trucks will directly **tread** them. Otherwise it may cause workers to topple over or the wirings to be broken, thus resulting in accidents.

WARNING

Do not install the control panel, interlock panel, operation stand, or else in places from which the movements of the robot are **out of sight**. When the robot movements go out of sight, even if an abnormality occurs in any movement, you will delay in taking notice of the abnormality, thus resulting in a disaster. Furthermore, you will not find someone near the robot to cause an accident.

WARNING

If the robot operating area required is smaller than the operable area possessed by the robot, **limit the robot operating area**. The area can be limited by using the software limit, limit switch, and mechanical stopper. Even if the robot exceeds the normal operating area due to an abnormality, this function will enable the robot to stop before initiating operation.

(For details, refer to information in the “Constant setting mode” section in the Operating Manual and also the Maintenance Manual.)

WARNING

Install **light shielding boards, enclosures**, and others to the extent that the movements of the robot can be monitored in directions in which workers may be exposed to spatters during welding. Otherwise it may cause injury to workers with welding arcs, spatters, or else.

WARNING

Provide **a large and highly visible display** of automatic and manual mode indicating the operating status of the robot so that it can be recognized even from locations at some distance. Furthermore, it is effective to provide audible alarm using a buzzer or announcement to alert workers to the initiation of automatic operation, thus facilitating awareness of automatic operation in progress from distant locations.

WARNING

Eliminate **protrusions** from the peripheral equipment and the like of the robot to a minimum. If necessary, be sure to cover them up. Otherwise it may induce a hazardous situation when a worker touches them or is surprised with a sudden movement of the robot to topple over.

WARNING

Do not attempt to install the robot so that a worker will need to **put his/her hands in the guard fence** to carry in or out workpieces. There may be cases where the robot moves when the worker put his/her hands in the guard fence.

Safety measures against installation work

The following section describes precautions for installing the robot. Fully understand the precautions for safe installation work.

WARNING

To install the robot, it is important to position the robot so that no workers will get pinched by the robot inside or around a device to use the robot. The robot must not come into contact with any peripheral equipment when operating in the maximum operating range with a tool mounted on it.

WARNING

Be sure to install the robot according to the specified procedure. Otherwise it will cause the robot to move or topple over while in operation, thus inducing an imminent hazardous situation.

WARNING

To make wire connections between the robot and the controller or the peripheral equipment, fully understand the connection procedure for proper wire connections. Making wire connections according to improper procedure will cause the robot to malfunction.

WARNING

Be sure to establish a proper ground for the robot. If equipment such as a welder that causes substantial noises is needed to use, establish the specified ground for the equipment.

WARNING

During transport or installation of the robot, pay utmost care not to cause damage to wirings. Furthermore, after installing the robot, take protective measures such as using protective guards so that the wirings will not be damaged by workers or other persons, or forklift trucks or else.

2.4.1 Installation location and ambient conditions

(1) Location with an ambient temperature ranging from 0°C to 45°C.
(2) Location with an ambient humidity ranging from 20 to 85%RH and no dew condensation.
(3) Location with the least dirt, dust, oily smoke, or water.
(4) Location with no flammable or corrosive fluid or gas.
(5) Location exposed to no substantial impact or vibration.
(6) Location not close to a substantial electric noise source.
(7) Location with a vibration value not more than 0.5G (equal to 4.9 m/s^2).

2.4.2 Installation procedure

While the robot is accelerating or decelerating the speed, large reaction force is applied to the swiveling base from all directions. Consequently, the robot should be installed in such a manner that the foundation endures reaction force caused by accelerating or decelerating the speed to lock the swiveling base, not to mention that it endures static loads.
To install the robot on the floor, if the floor concrete is not less than 160 mm in thickness, repair uneven spots, cracks, and others on the floor, and then install the robot with the use of eight bolts (option) of not less than M20×65 (JIS: Strength class 12.9) and plain washers (option) of not less than 4.5 mm in thickness and HRC35 in hardness. At this time, apply a coating of lubricating oil to the threaded parts of the bolts, and then torque the bolts to 560±30 N·m.
If the floor concrete is not more than 160 mm in thickness, an independent foundation should be constructed. Inspect the foundation prior to the robot installation, and then construct the foundation, if necessary.

[Table 2.3.2] Allowable load of foundation bolt

Robot Model	Allowable repeated tensile load per foundation bolt when the robot is installed with eight bolts
ST133F-01, ST166F-01	Approximately 40000 N
ST210F-01	Approximately 48000 N
ST133TF-01, ST166TF-01	Approximately 53000 N
ST210TF-01	Approximately 64000 N

2.4.3 Installation space

To install the robot, lock the swiveling base of the robot.

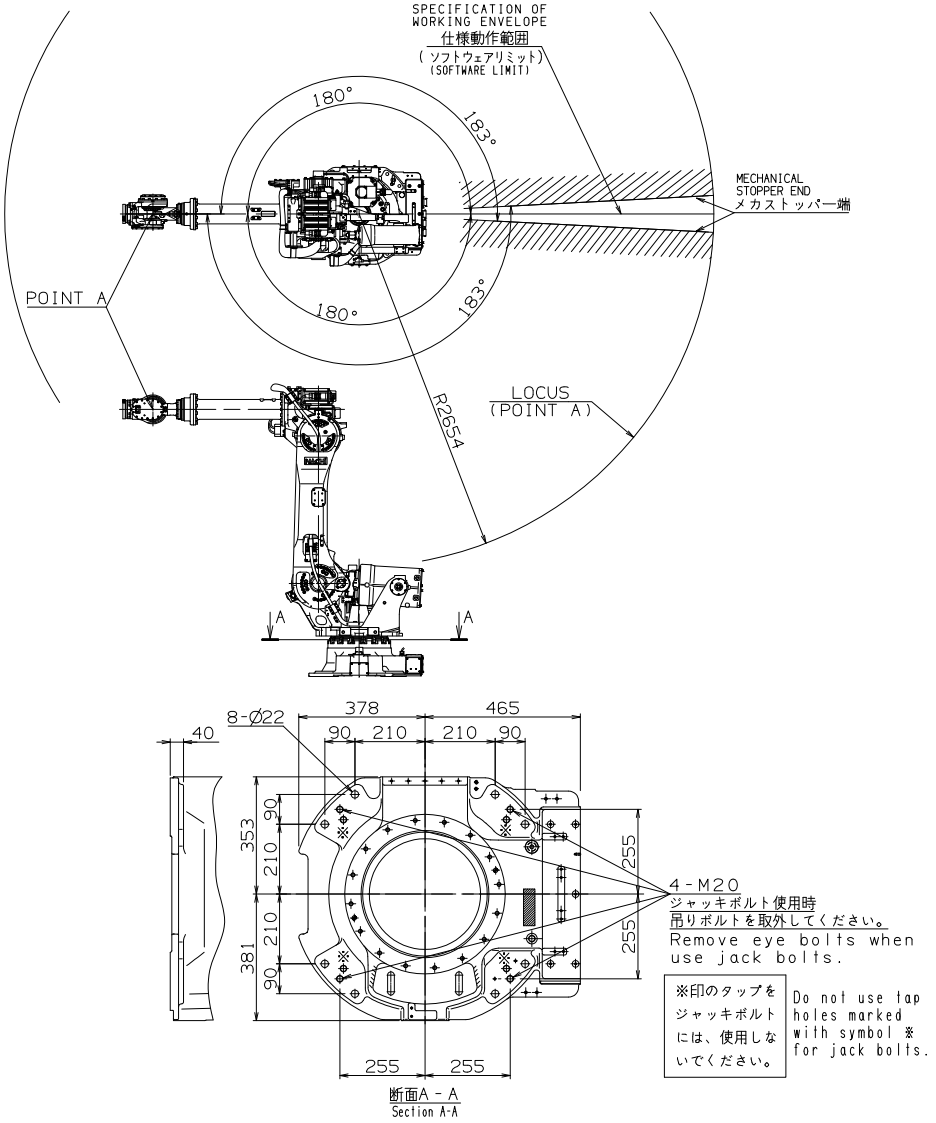
WARNING

The mechanical stopper end is located in a position exceeding the specified operating range (software limit) of the J1 axis by 3°. To install the guard fence, refer to the figures in this section with consideration given to the wrist configuration and the shape of end effector.

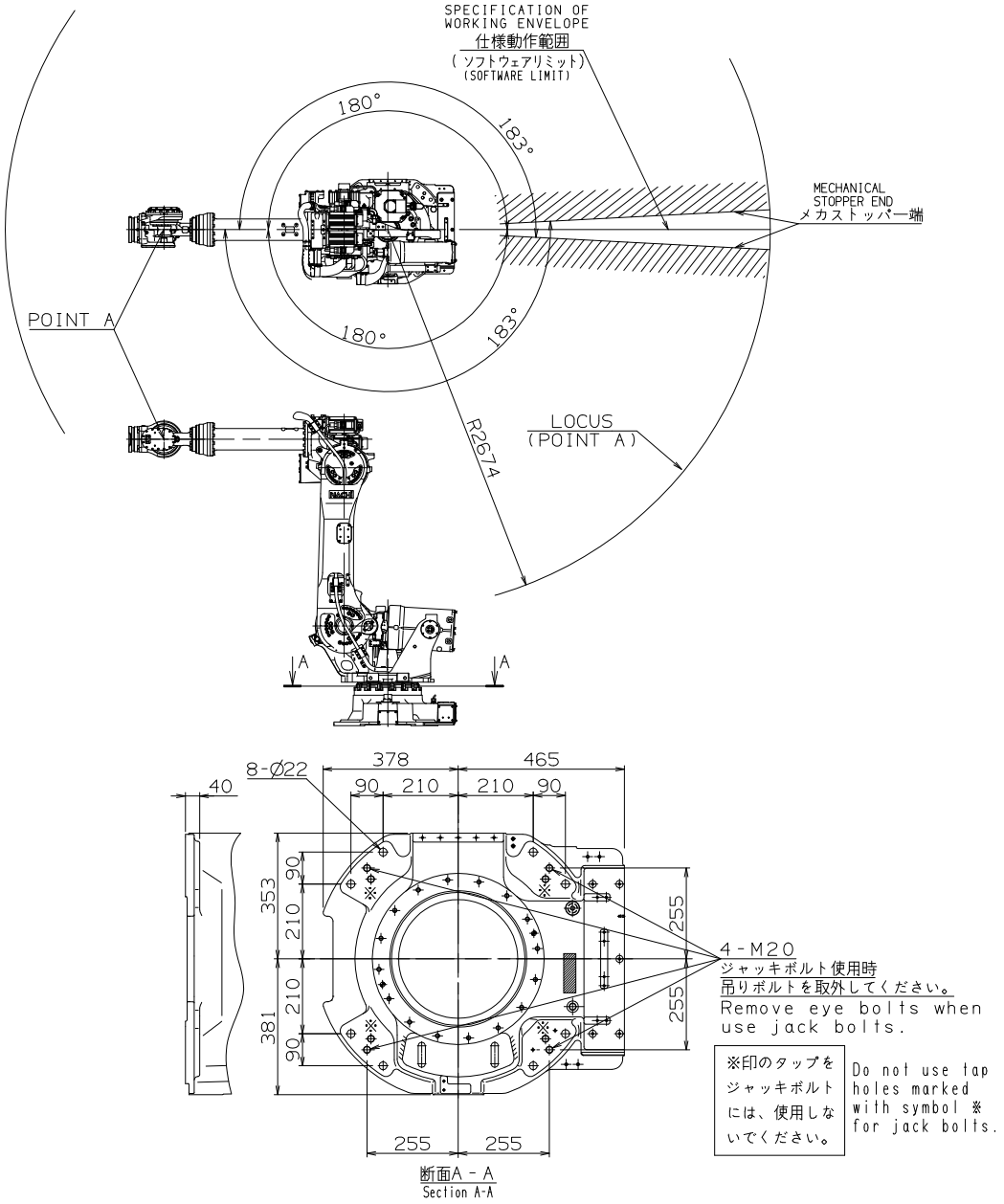
WARNING

On the J1, J2, and J3 axes, the robot operating range can be regulated for safety (optional function). Since optional parts (e.g. limit switches or additional stopper blocks) should be installed to enable this function, do not independently move the standard parts (e.g. stopper block).

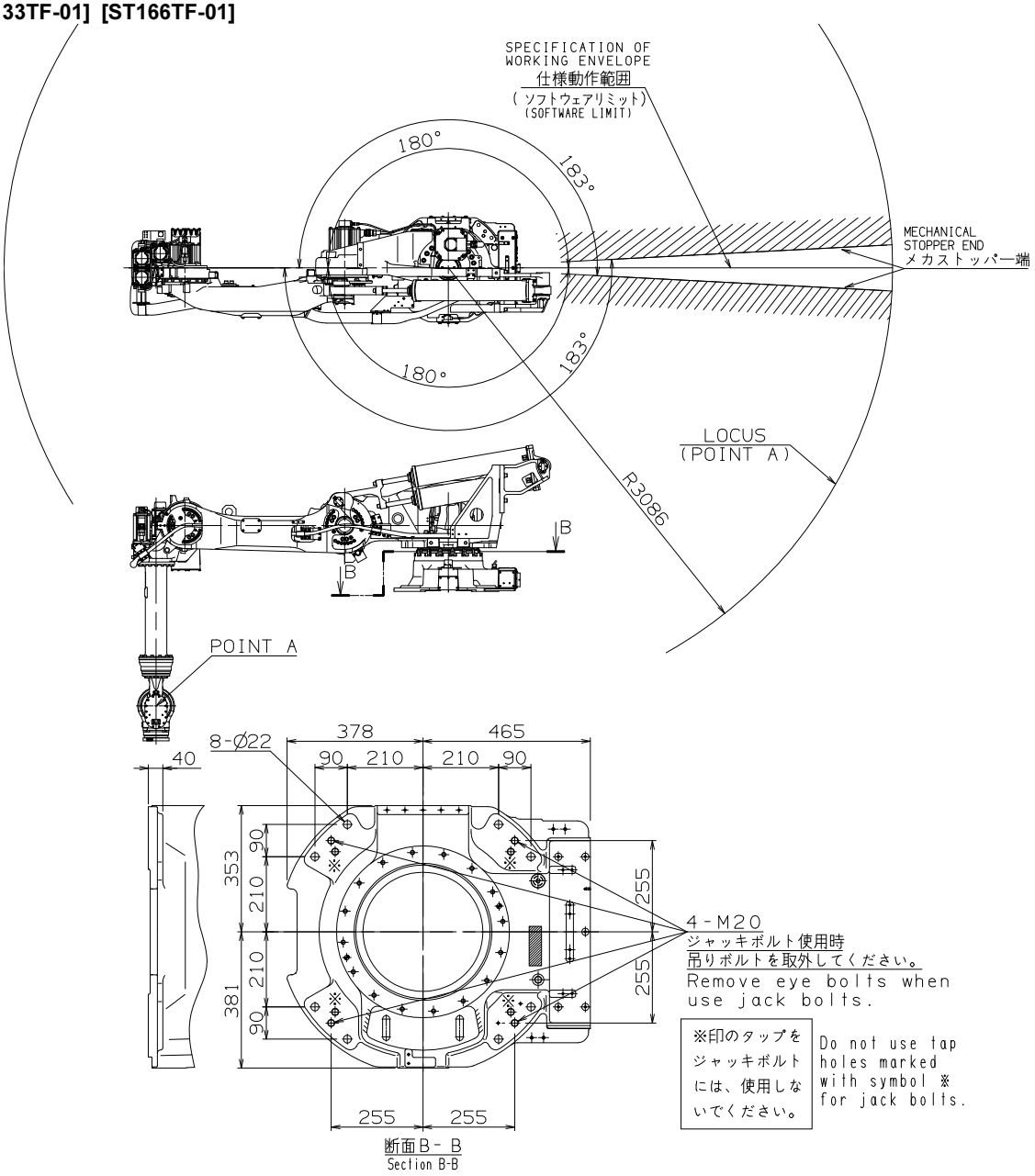
[ST133F-01] [ST166F-01]



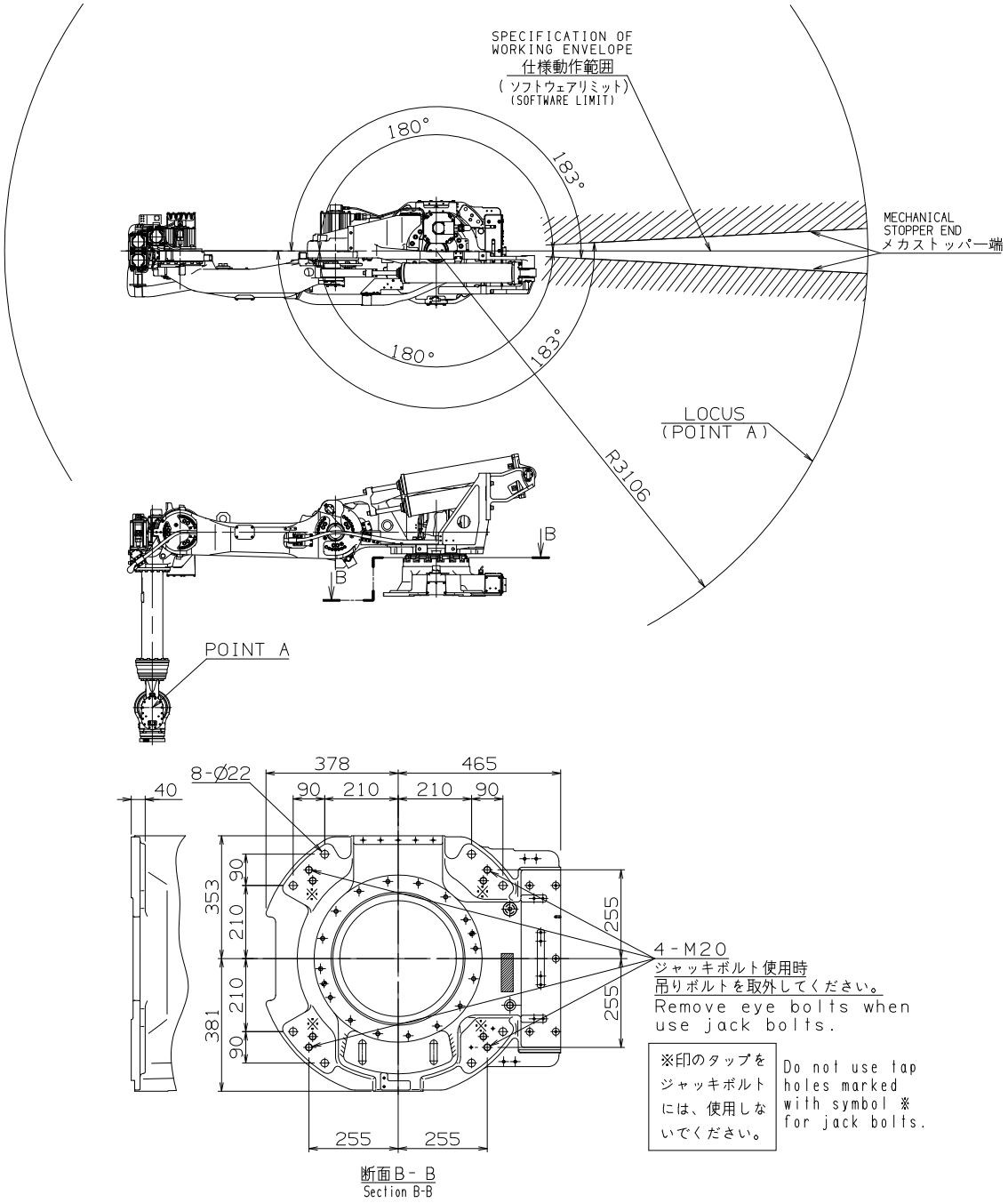
[ST210F-01]


SPECIFICATION OF
WORKING ENVELOPE
仕様動作範囲
(ソフトウェアリミット)
(SOFTWARE LIMIT)
180°
183°
MECHANICAL
STOPPER END
メカストッパー端
POINT A
180°
183°
R2674
LOCUS
(POINT A)
A
A
8-Ø22
378
465
40
90
210
210
90
353
90
210
210
90
381
255
255
4-M20
ジャッキボルト使用時
吊りボルトを取外してください。
Remove eye bolts when
use jack bolts.
※印のタップを
ジャッキボルト
には、使用しな
いでください。
Do not use tap
holes marked
with symbol ※
for jack bolts.
255
255
断面A - A
Section A-A

[ST133TF-01] [ST166TF-01]



[ST210TF-01]


SPECIFICATION OF
WORKING ENVELOPE
仕様動作範囲
(ソフトウェアリミット)
(SOFTWARE LIMIT)
180°
183°
180°
183°
MECHANICAL
STOPPER END
メカストッパー端
LOCUS
(POINT A)
R3106
B
B
POINT A
8-Ø22
378
465
40
90
210
210
90
353
90
210
210
381
90
255
255
4-M20
ジャッキボルト使用時
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use jack bolts.
※印のタップを
ジャッキボルト
には、使用しな
いでください。
Do not use tap
holes marked
with symbol ※
for jack bolts.
255
255
断面B-B
Section B-B

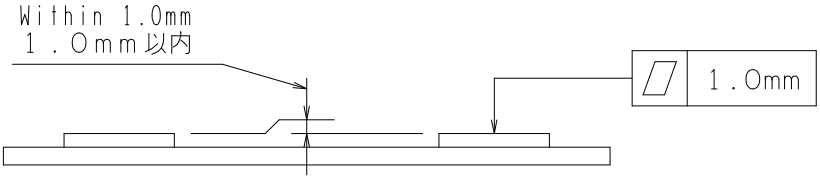
2.4.4 Accuracy of installation surface

In order to install the robot, strictly observe precautions listed below to cause no deformation in the swiveling base.

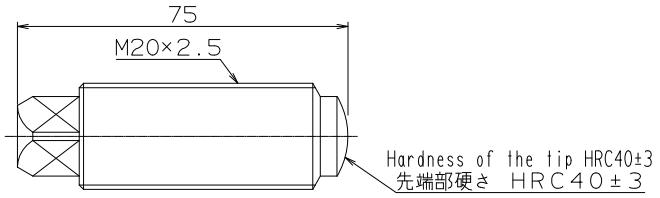
• Precautions

(1) Make the deviation from the flatness of the four plates on the robot installation surface fall within 1 mm.

(2) Make the deviation in height between the four places of each base plate installation surface and the robot installation surface fall in the range of 1.0(±0.5) mm.



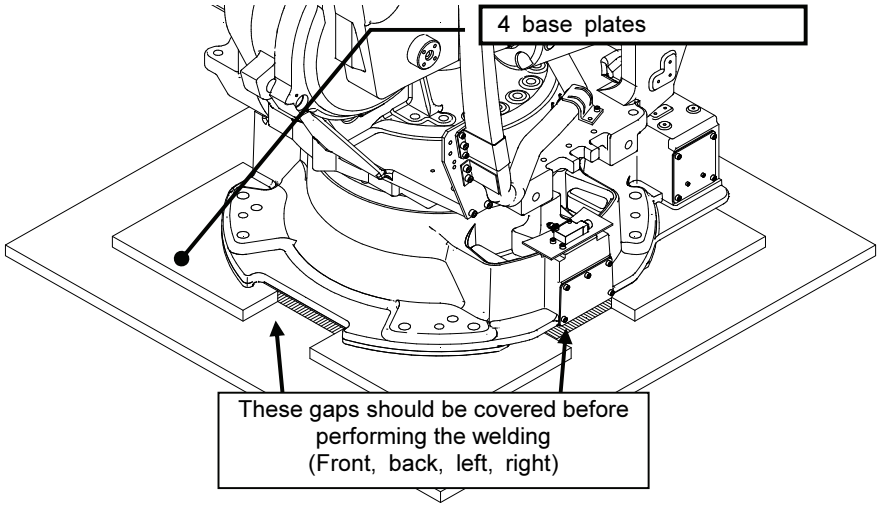
(3) If the two precautions above cannot be observed, use jack bolts to bring the four places into even contact with the installation surface.



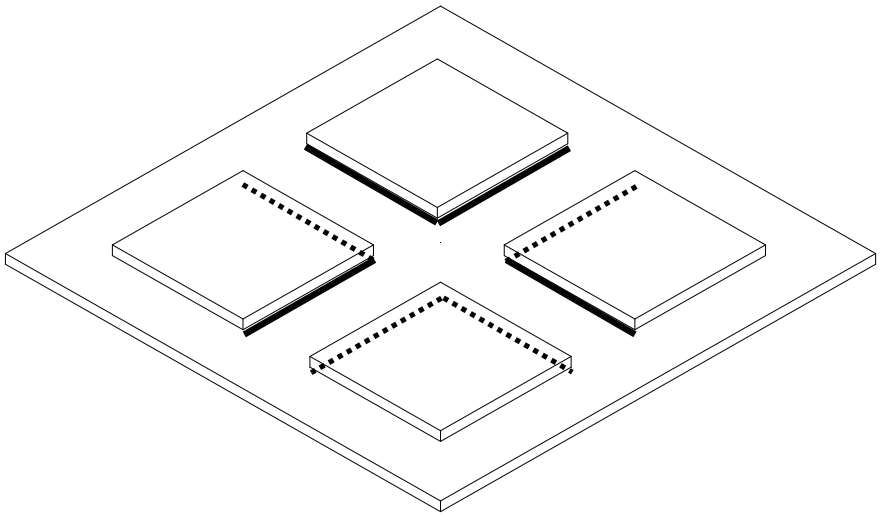
CAUTION

The internal wirings inside the robot base unit may be burned or damaged because of welding spatters or sparks. Therefore, when welding the base plates with attatched to the robot base unit, please cover the gaps shown in the following picture in advance.

(1) Put the robot temporary to fix its position, and perform welding on the outside of base plates.



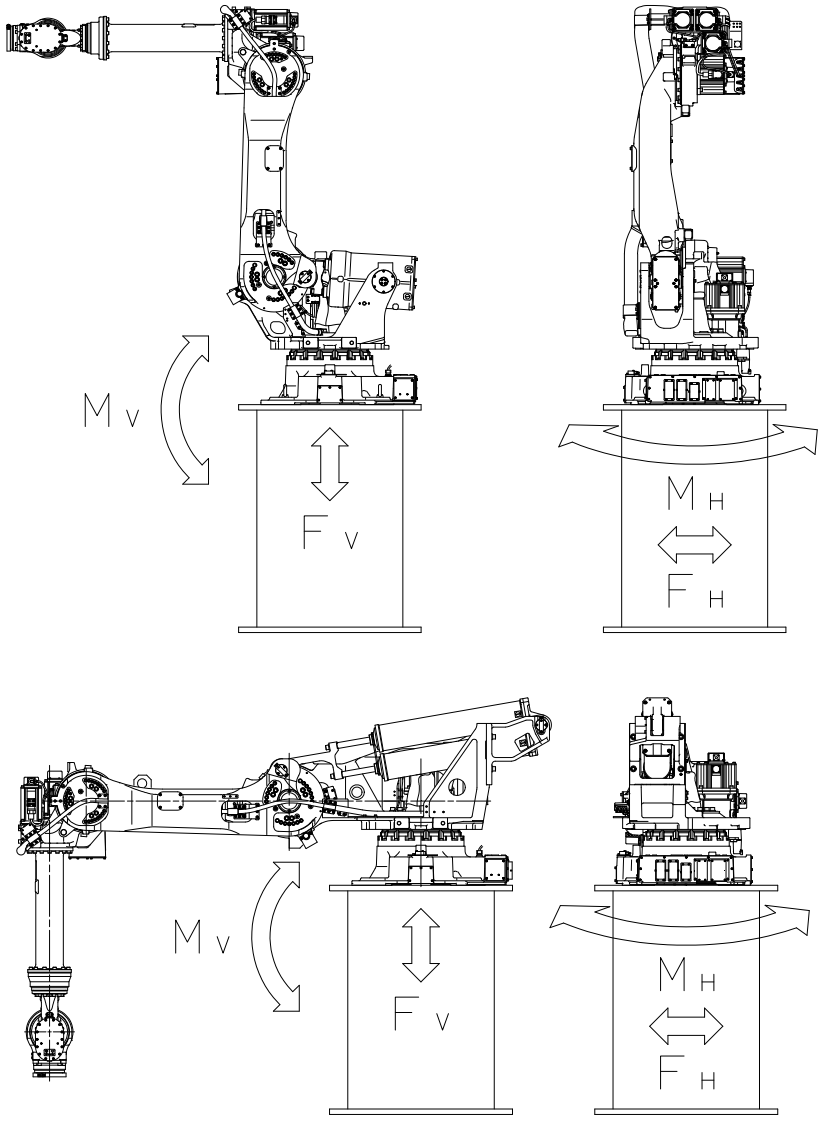
(2) Remove the robot, and perform welding on the inside of base plates.



(3) Install the robot.

2.4.5 Maximum robot generative force

Robot Model	Maximum vertical generative force F_V	Maximum horizontal generative force F_H	Maximum vertical generative moment M_V	Maximum horizontal generative moment M_H
ST133F-01 ST166F-01	48,700 N	34,800 N	92,400 N·m	79,900 N·m
ST210F-01	54,000 N	39,700 N	111,300 N·m	96,700 N·m
ST133TF-01 ST166TF-01	55,500 N	41,000 N	123,600 N·m	107,000 N·m
ST210TF-01	62,000 N	46,700 N	148,500 N·m	129,100 N·m



2.5 Allowable wrist load

CAUTION

A load fixed to the tip of the robot wrist is regulated by the allowable pay load mass, allowable static load torque, and allowable moment of inertia.
Furthermore, the allowable load torque varies with the actual load inertia moment.

Strictly keep the wrist load within each allowable value. If wrist load exceeds the allowable value, this robot is out of guarantee.

(1) Allowable pay load mass

Robot Model	Allowable pay load mass
ST133F-01, ST133TF-01	Not more than 133 kg
ST166F-01, ST166TF-01	Not more than 166 kg
ST210F-01, ST210TF-01	Not more than 210 kg

(2) Allowable maximum static load torque

Robot Model	Allowable static load torque		
	Around J4 axis	Around J5 axis	Around J6 axis
ST133F-01, ST133TF-01	Not more than 745 N·m	Not more than 745 N·m	Not more than 411 N·m
ST166F-01, ST166TF-01	Not more than 951 N·m	Not more than 951 N·m	Not more than 490 N·m
ST210F-01, ST210TF-01	Not more than 1337 N·m	Not more than 1337 N·m	Not more than 720 N·m

Referring to ”2.5.1 Torque map”, use the robot wrist on condition that the load gravity center falls in the range shown in the wrist torque map.

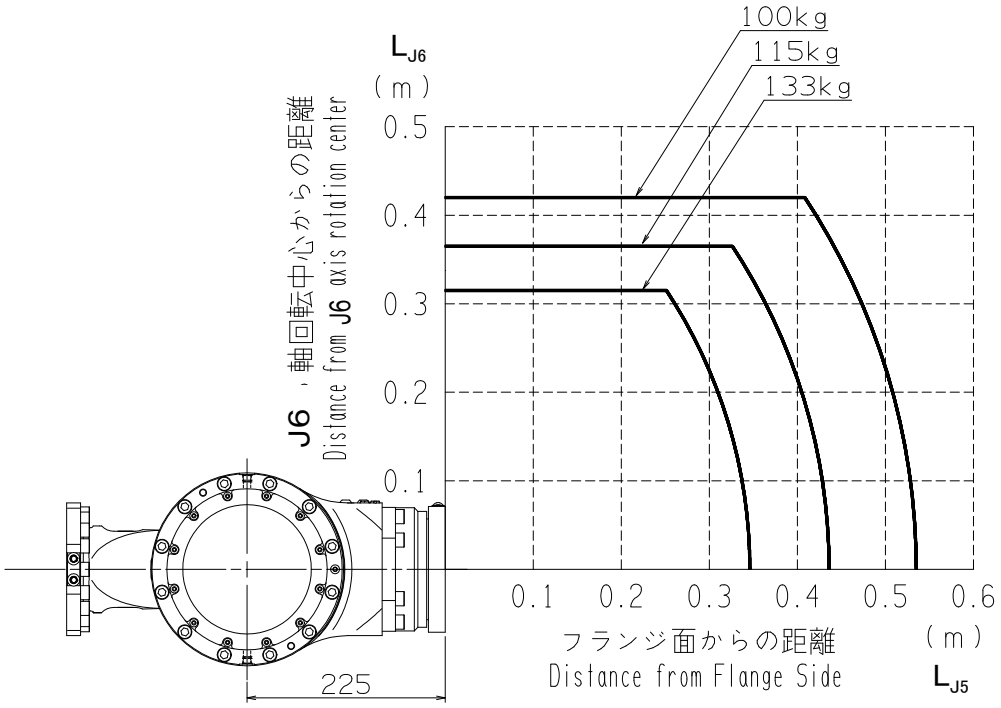
(3) Allowable maximum inertia moment

Robot Model	Allowable inertial moment		
	Around J4 axis	Around J5 axis	Around J6 axis
ST133F-01, ST133TF-01	Not more than 60.9 kg·m^2	Not more than 60.9 kg·m^2	Not more than 30.2 kg·m^2
ST166F-01, ST166TF-01	Not more than 88.9 kg·m^2	Not more than 88.9 kg·m^2	Not more than 45.0 kg·m^2
ST210F-01, ST210TF-01	Not more than 141.1 kg·m^2	Not more than 141.1 kg·m^2	Not more than 79.0 kg·m^2

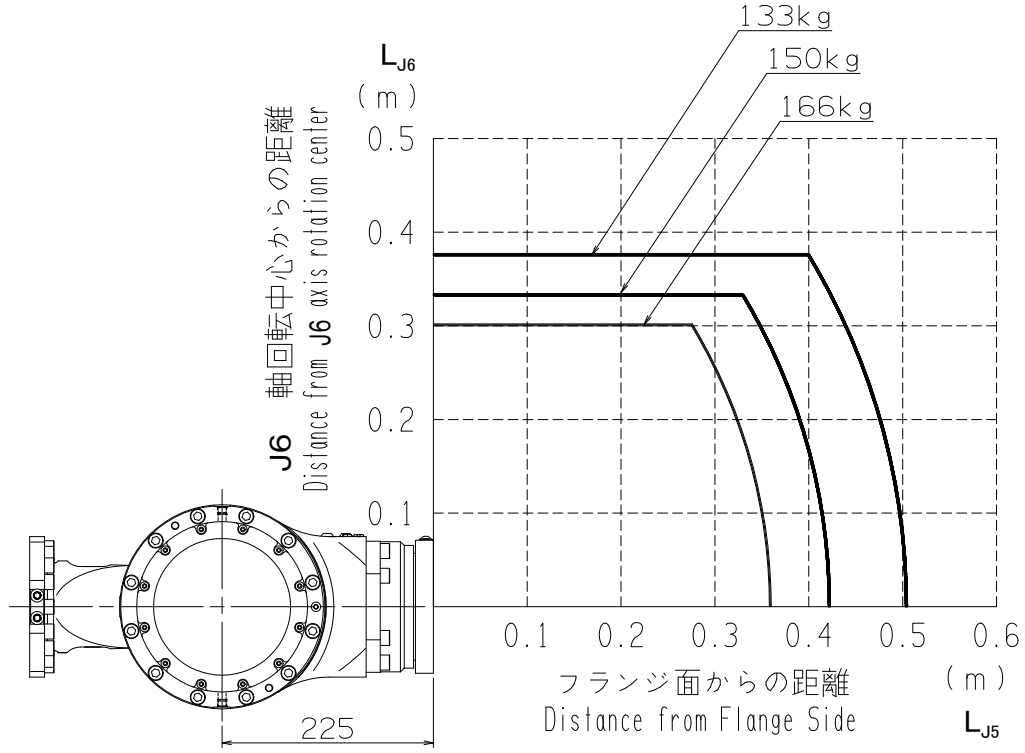
Referring to ”2.5.2 Wrist load conditions”, use the robot wrist on condition that the static load torque and the moment of inertia fall in the range shown by the diagram in the wrist torque map.

2.5.1 Torque map

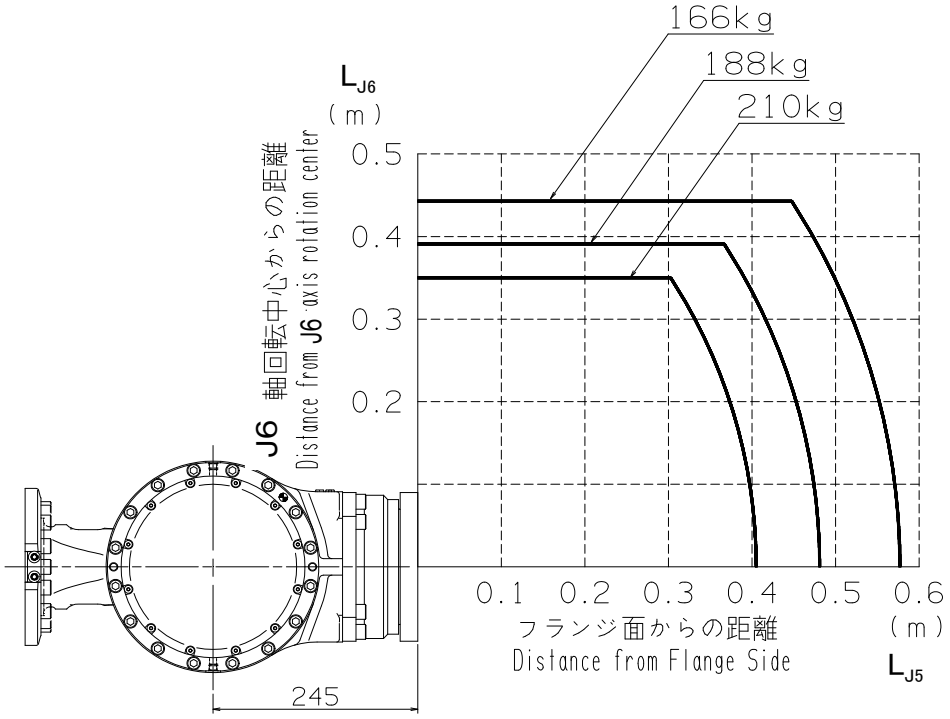
[ST133F-01] [ST133TF-01]



[ST166F-01] [ST166TF-01]



[ST210F-01] [ST210TF-01]

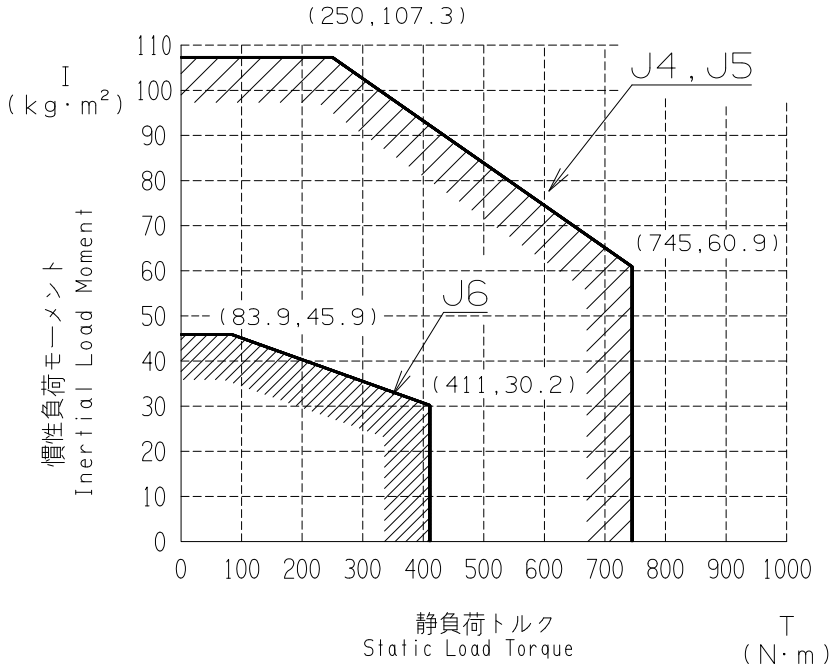


2.5.2 Wrist load conditions

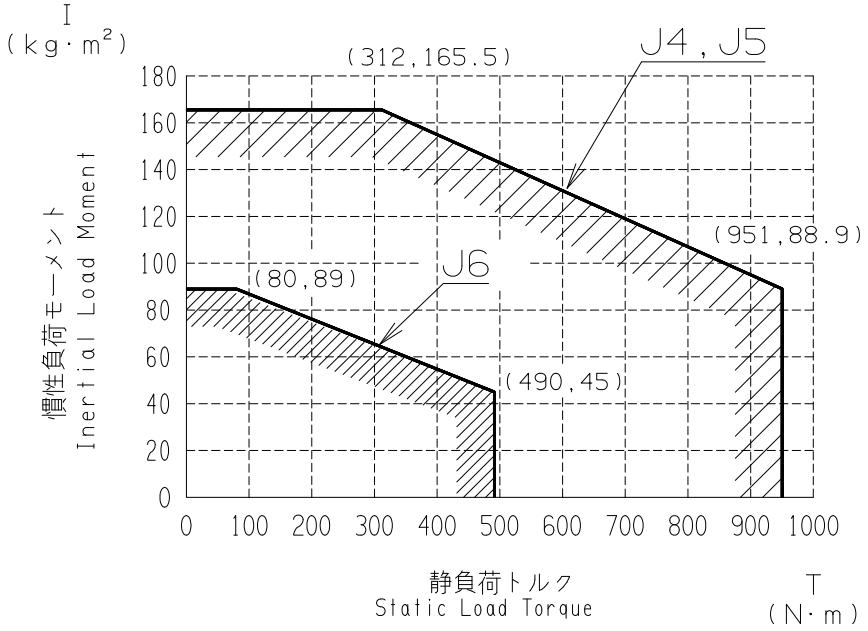
CAUTION

If the real inertia of load moment is over the limit written on the specification sheet, maximum speed will be restrained.
(This curve is available on software version AXV08.23 or later.)

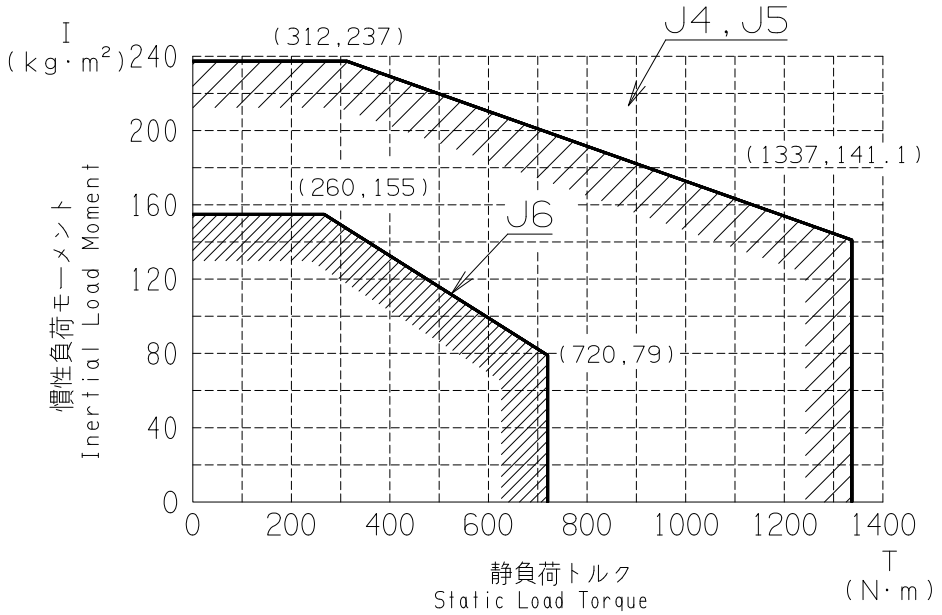
[ST133F-01] [ST133TF-01]



[ST166F-01] [ST166TF-01]



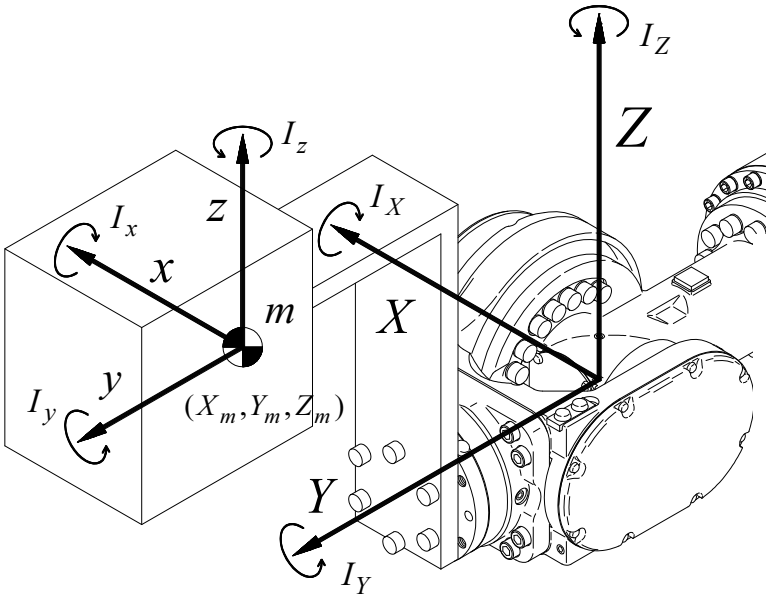
[ST210F-01] [ST210TF-01]



2.5.3 How to find the inertia moment of each axis

[ST133F-01] [ST166F-01] [ST210F-01] [ST133TF-01] [ST166TF-01] [ST210TF-01]

The following section shows general methods of calculating the inertia moment around each axis.



X: Axis for J5 axis rotation in the basic wrist configuration
Y: Axis for J6 and J4 axis rotation in the basic wrist configuration
Z: Axis at right angles to the X and Y axes in the basic wrist configuration
x: Axis parallel to the X axis in the load gravity center
y: Axis parallel to the Y axis in the load gravity center
z: Axis parallel to the Z axis in the load gravity center
I_x: Inertia moment around the X axis passing through the load gravity center
I_y: Inertia moment around the Y axis passing through the load gravity center
I_z: Inertia moment around the Z axis passing through the load gravity center
m: Load mass
(X_m, Y_m, Z_m): Gravity center coordinates of load

Fig. 2.5.3-1 Schematic diagram of wrist load

(1) Inertia moment around J6 axis

The inertia moment of around the J6 axis is found by the expression shown below.

$$I_{J6} = I_Y = m \cdot (X_m{}^2 + Z_m{}^2) + I_y$$

(2) Inertia moment around J4 and J5 axes

The inertia moment around the J4 and J5 axes varies with the J6-axis configuration. Consequently, in order to simplify the calculation, take a maximum value around the X and Z axes in Fig. 2.5.3-1 as the inertia moment.

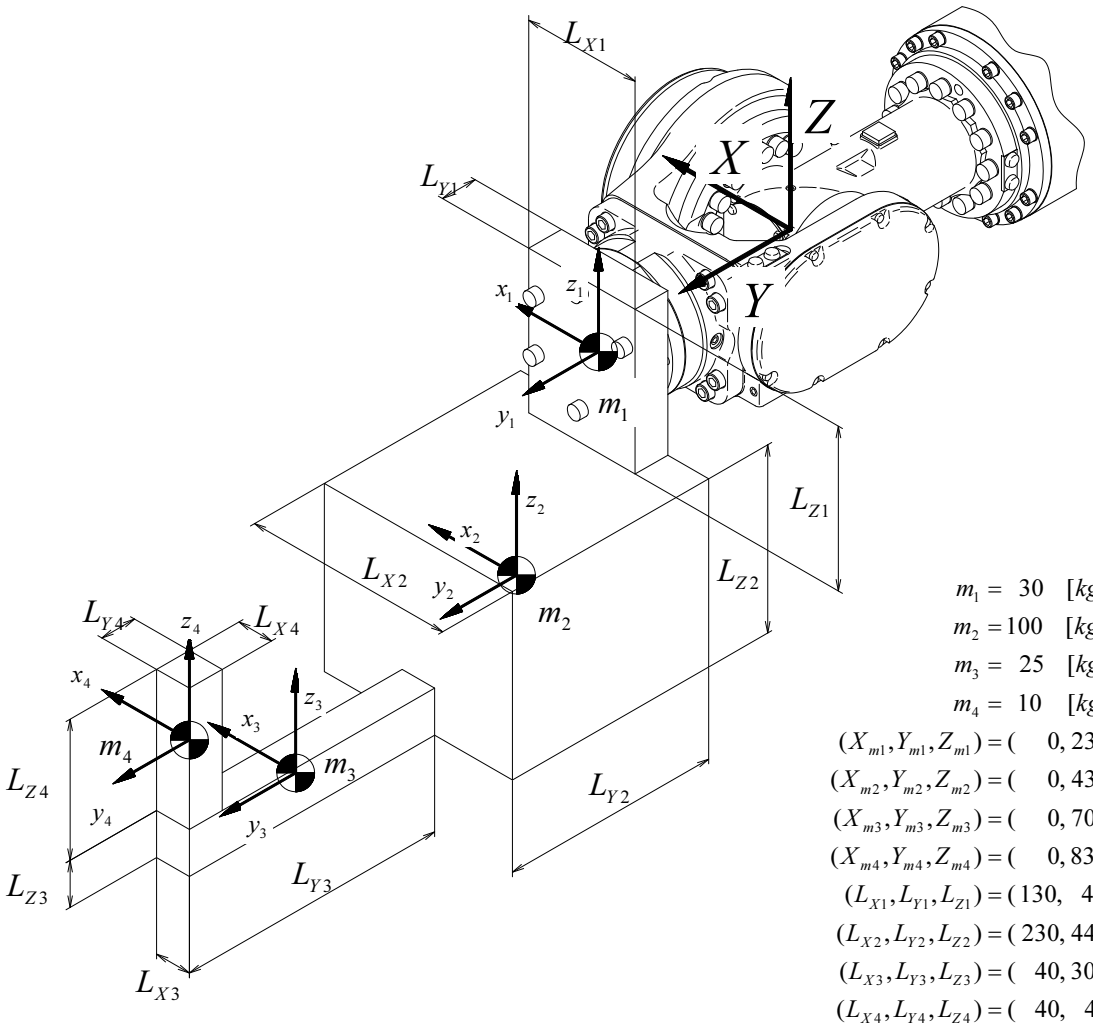
$$I_{J4J5} = \max \underbrace{(I_X , I_Z)}$$

Select a value whichever larger.

$$\because I_X = m \cdot (Y_m{}^2 + Z_m{}^2) + I_x$$

$$\because I_Z = m \cdot (X_m{}^2 + Y_m{}^2) + I_z$$

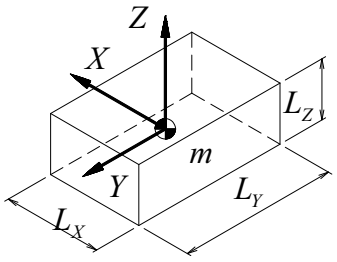
Then, for example, perform a calculation for a load shown in Fig. 2.5.3-2.
If the gravity center coordinates for the whole load and the inertia moment around the gravity center are already known, the calculation will be easily performed. Since the load generally has complicated shapes, however, divide the load roughly into several blocks, and then perform the calculation of inertia moment.
Furthermore, dividing the load into as many blocks as possible will improve the accuracy of calculation.



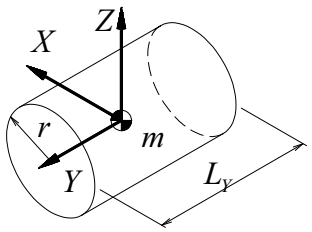
$$
\begin{aligned}
m_1 &= 30 \quad [kg] \\
m_2 &= 100 \quad [kg] \\
m_3 &= 25 \quad [kg] \\
m_4 &= 10 \quad [kg] \\
(X_{m1}, Y_{m1}, Z_{m1}) &= (\ 0, 235, \ 0) \quad [mm] \\
(X_{m2}, Y_{m2}, Z_{m2}) &= (\ 0, 435, -300) \quad [mm] \\
(X_{m3}, Y_{m3}, Z_{m3}) &= (\ 0, 705, -375) \quad [mm] \\
(X_{m4}, Y_{m4}, Z_{m4}) &= (\ 0, 835, -275) \quad [mm] \\
(L_{X1}, L_{Y1}, L_{Z1}) &= (130, \ 40, \ 200) \quad [mm] \\
(L_{X2}, L_{Y2}, L_{Z2}) &= (230, 440, 400) \quad [mm] \\
(L_{X3}, L_{Y3}, L_{Z3}) &= (\ 40, 300, \ 50) \quad [mm] \\
(L_{X4}, L_{Y4}, L_{Z4}) &= (\ 40, \ 40, 350) \quad [mm]
\end{aligned}
$$

Fig. 2.5.3-2 Example of wrist load calculation

Then, the following section shows the expression to perform calculations of the inertia moment of major shapes.



$$
\begin{aligned}
I_X &= m \cdot (L_Y{}^2 + L_Z{}^2)/12 \\
I_Y &= m \cdot (L_X{}^2 + L_Z{}^2)/12 \\
I_Z &= m \cdot (L_X{}^2 + L_Y{}^2)/12
\end{aligned}
$$



$$
\begin{aligned}
I_X &= I_Z = m \cdot (r^2/4 + L_Y{}^2/12) \\
I_Y &= (m \cdot r^2)/2
\end{aligned}
$$

Fig. 2.5.3-3 Inertia moment of major shapes

(1) Inertia moment around J6 axis

$$
\begin{aligned}
I_{J6} &= I_Y \\
&= \sum (m \cdot ({X_m}^2 + {Z_m}^2) + I_y) \\
&= m_1 \cdot ({X_{m1}}^2 + {Z_{m1}}^2) + m_2 \cdot ({X_{m2}}^2 + {Z_{m2}}^2) + m_3 \cdot ({X_{m3}}^2 + {Z_{m3}}^2) + m_4 \cdot ({X_{m4}}^2 + {Z_{m4}}^2) + I_{y1} + I_{y2} + I_{y3} + I_{y4} \\
&= 30 \cdot (0^2 + 0^2) + 100 \cdot (0^2 + (-300)^2) + 25 \cdot (0^2 + (-375)^2) + 10 \cdot (0^2 + (-275)^2) + \\
&\quad 30 \cdot (130^2 + 200^2)/12 + 100 \cdot (230^2 + 400^2)/12 + 25 \cdot (40^2 + 50^2)/12 + 10 \cdot (40^2 + 350^2)/12 \\
&= 15300250 \quad [kg \cdot mm^2] \\
&= 15.3 \quad [kg \cdot m^2]
\end{aligned}
$$

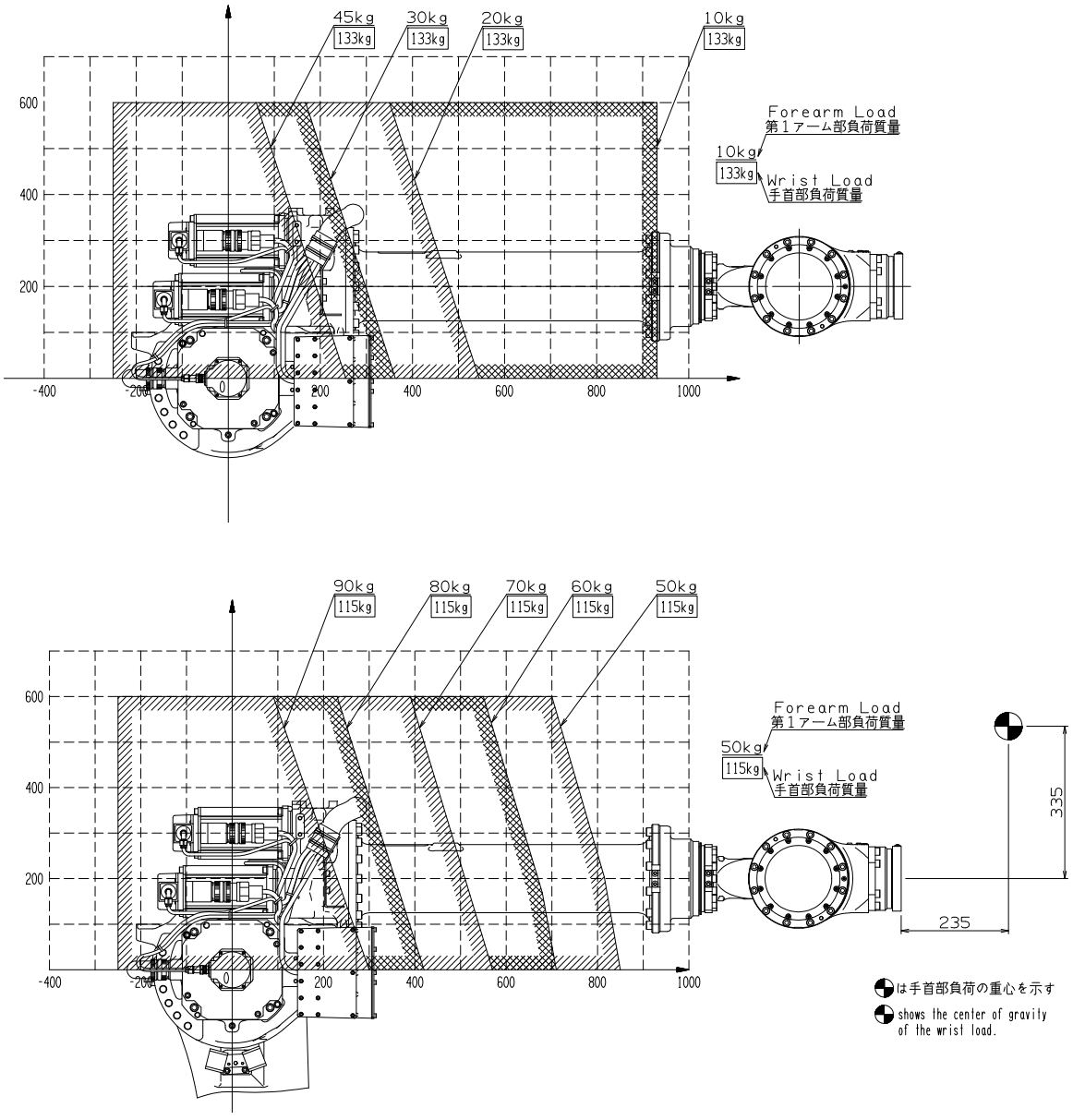
(2) Inertia moment around J4,J5 axis

$$
\begin{aligned}
I_X &= \sum (m \cdot ({Y_m}^2 + {Z_m}^2) + I_x) \\
&= m_1 \cdot ({Y_{m1}}^2 + {Z_{m1}}^2) + m_2 \cdot ({Y_{m2}}^2 + {Z_{m2}}^2) + m_3 \cdot ({Y_{m3}}^2 + {Z_{m3}}^2) + m_4 \cdot ({Y_{m4}}^2 + {Z_{m4}}^2) + I_{x1} + I_{x2} + I_{x3} + I_{x4} \\
&= 30 \cdot (235^2 + 0^2) + 100 \cdot (435^2 + (-300)^2) + 25 \cdot (705^2 + (-375)^2) + 10 \cdot (835^2 + (-275)^2) + \\
&\quad 30 \cdot (40^2 + 200^2)/12 + 100 \cdot (440^2 + 400^2)/12 + 25 \cdot (300^2 + 50^2)/12 + 10 \cdot (40^2 + 350^2)/12 \\
&= 56595792 \quad [kg \cdot mm^2] \\
&= 56.6 \quad [kg \cdot m^2] \\
I_Z &= \sum (m \cdot ({X_m}^2 + {Y_m}^2) + I_z) \\
&= m_1 \cdot ({X_{m1}}^2 + {Y_{m1}}^2) + m_2 \cdot ({X_{m2}}^2 + {Y_{m2}}^2) + m_3 \cdot ({X_{m3}}^2 + {Y_{m3}}^2) + m_4 \cdot ({X_{m4}}^2 + {Y_{m4}}^2) + I_{z1} + I_{z2} + I_{z3} + I_{z4} \\
&= 30 \cdot (0^2 + 235^2) + 100 \cdot (0^2 + 435^2) + 25 \cdot (0^2 + 705^2) + 10 \cdot (0^2 + 835^2) + \\
&\quad 30 \cdot (130^2 + 40^2)/12 + 100 \cdot (230^2 + 440^2)/12 + 25 \cdot (40^2 + 300^2)/12 + 10 \cdot (40^2 + 40^2)/12 \\
&= 42271041 \quad [kg \cdot mm^2] \\
&= 42.3 \quad [kg \cdot m^2] \\
\therefore I_{J4,J5} &= 56.6 \quad [kg \cdot m^2]
\end{aligned}
$$

2.6 Allowable forearm load

Ancillary equipment can be mounted to the upper part of robot forearm. If the wrist load mass is maximum, use the ancillary equipment on the load condition that the load gravity center falls in the shaded range, referring to the following figures. Furthermore, if the wrist load mass is small, the ancillary equipment of 90 kg at maximum can be mounted according to the mass and gravity center position. For details, request the technical information to our Technical Department.

[ST133F-01] [ST133TF-01]



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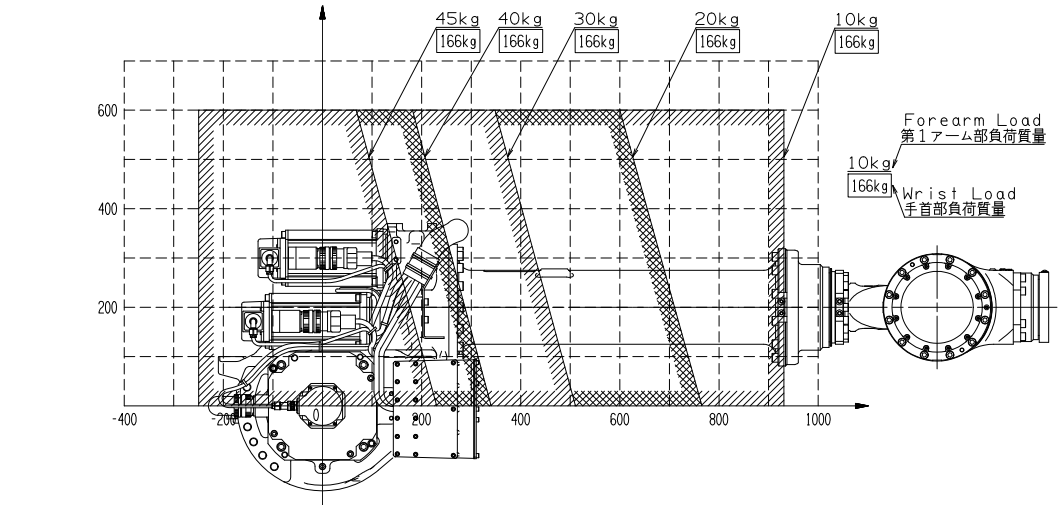
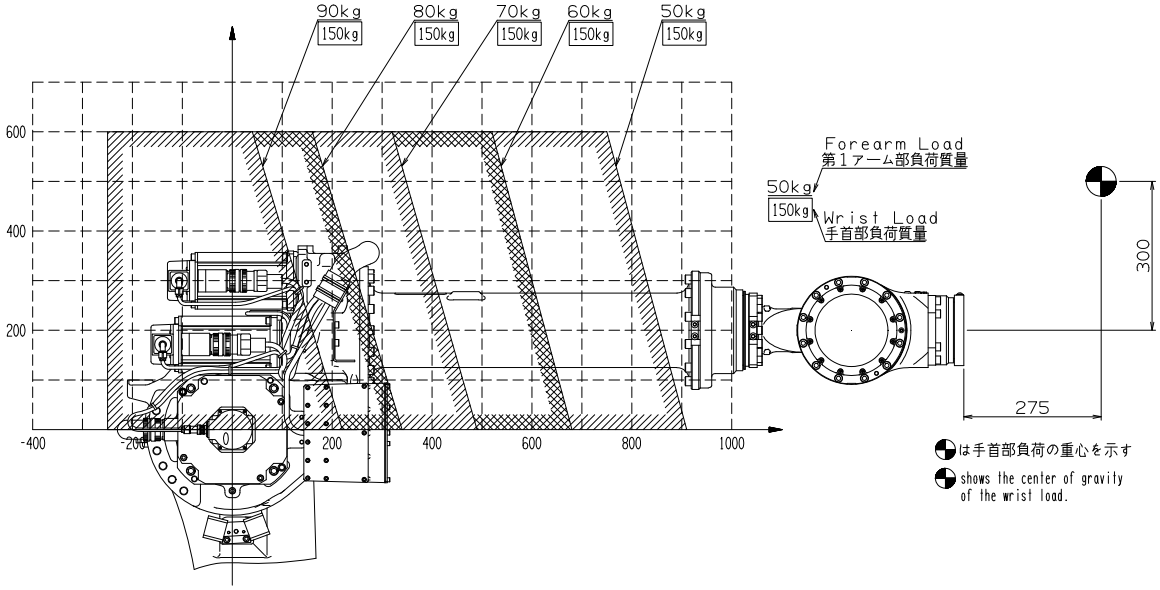
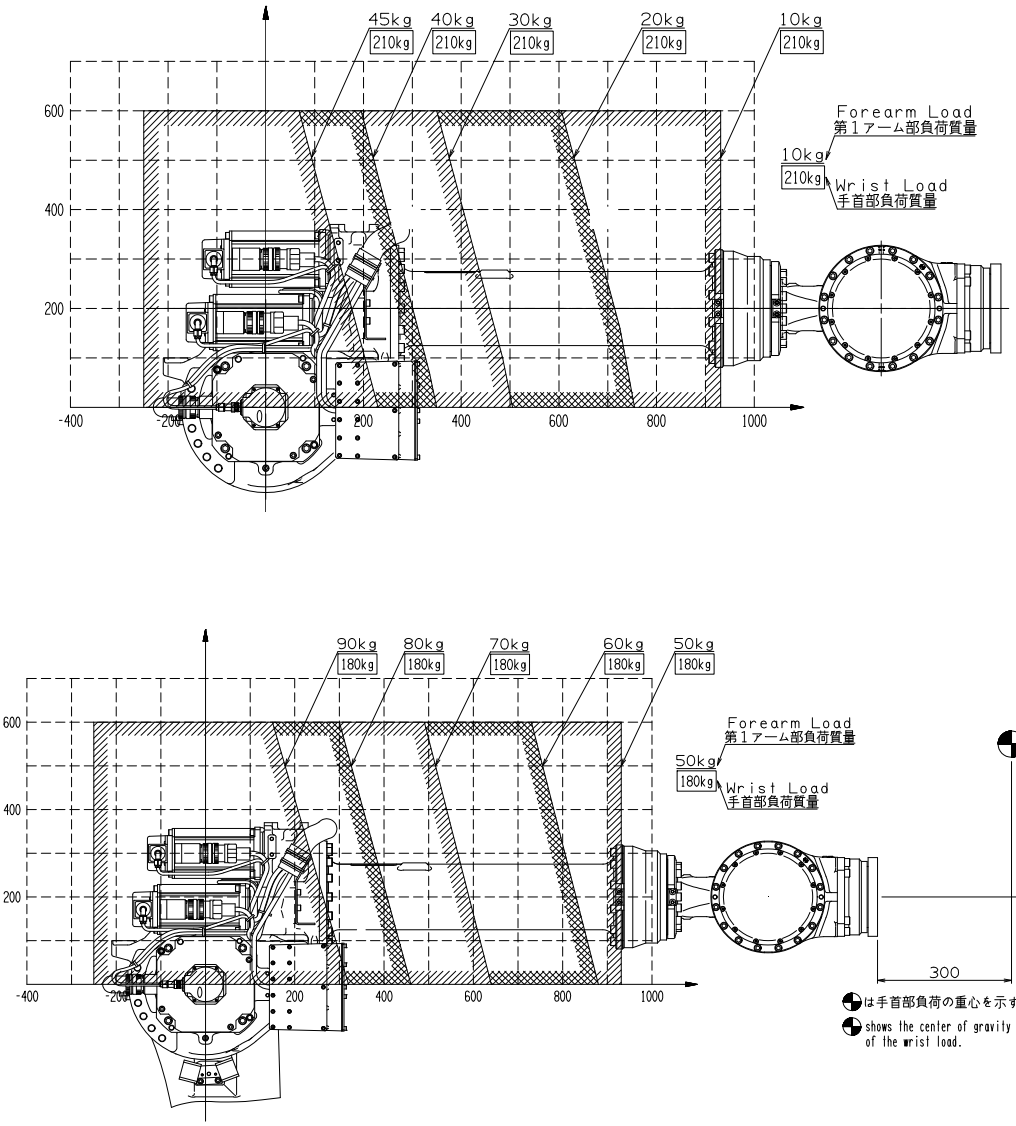




[ST210F-01] [ST210TF-01]



2.7 Execution of encoder correction

CAUTION

At NACHI factory, encoder correction is performed under the load condition and robot posture specified by NACHI. This load condition and robot posture may have influence on the reference position. So please perform encoder correction for all axes
after all of the load are mounted on wrist and upper arm,
before staring the teaching procedure,
by referring to information in “5.4.4 Encoder Correction”. (At this time, encoder resetting procedure is not required.) If encoder correction is carelessly performed after teaching is done, all of the taught points are needed to be modified because tool top position may change largely.

CAUTION

Also encoder correction is necessary when motor / encoder is replaced.

At this time, encoder correction must be performed under the **same load condition and same robot posture as the first time encoder correction that is performed immediately after the loads are mounted**, because load condition and robot posture may have influence on the reference position. Therefore, the “reference posture” (where all axes are in “reference position” by using zeroing pin or like that) is recommended as the posture of encoder correction. (refer to “5.4.4 Encoder Correction”)

Furthermore, sometimes normal encoder correction is not sufficient to recover the taught positions precisely in case that bigger tool is mounted, etc. In such case, more accurate encoder correction procedure is recommended by referring to “5.4.5 More accurate encoder correction”.

Chapter 3 Inspection

Maintenance and inspection

WARNING

The maintenance and inspection of the robot must be performed by personnel who received special instructor education or education for a period of hours provided by law and further really knows how to perform the maintenance and inspection on the robot.

WARNING

To perform the maintenance and inspection, be sure to check for safety around the robot and ensure safe corridors and shelters to escape from hazardous situations.

WARNING

To perform daily inspection, repair, or part replacement of the robot, be sure to turn OFF the power supply. Furthermore, in order to prevent other workers from improperly turning ON the power supply, post the warning signs such as “DON’T POWER ON” at the primary power supply switch and others.

WARNING

To replace any parts, be sure to use specified parts.

For details, refer to information in the “List of Maintenance Parts” of the “AX Controller Maintenance Manual” and the “Recommended Spare Parts” of the “Robot Maintenance Manual”.

WARNING

To perform the maintenance and inspection, if hazardous situations are induced by the drop or move of the robot arm, be sure to lock the arm.

For details, refer to information in the “Motor replacement” section in the “Trouble shooting” in the “Service Maintenance Manual” for the robot.

DANGER

The balance spring device is internally compressed even in the normal state. Never attempt to dismount or disassemble this device. Otherwise it will result in a highly hazardous situation.

3.1 Inspection items and periods

The inspection should be performed in order to maintain the high performance of the robot for an extended period of time. The inspection includes daily inspection and periodical inspection. According to the basic inspection periods shown below, personnel who are engaged in the inspection must create and implement the inspection program. For inspection items, refer to following table.
Furthermore, perform overhauls **every 40,000 operating hours or every 8 years, whichever comes earlier.** The inspection periods have been examined for spot welding work. For high frequency of works such as handling work, it is recommended to perform inspections **at approximately 1/2 of the periods specified.**
Should you have any questions about the inspection and adjustment methods, contact your NACHI representative or our Technical Department.

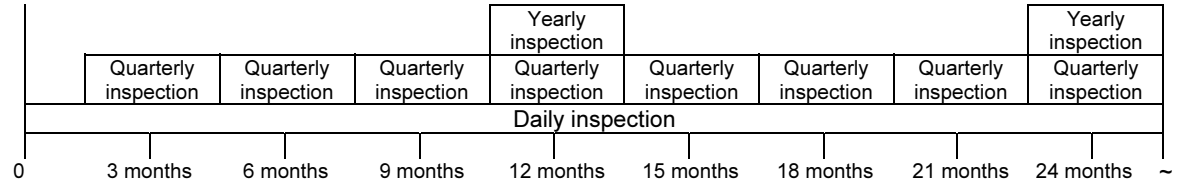


Fig. 3.1 Inspection program

[Table 3.1] Inspection items and periods

No.	Period			Inspection Item	Inspection Method	Criterion	Remark
	Daily	Quarterly	Yearly				
Common to Whole Robot and Each Axis							
1	O			Cleaning of robot	• Wiping of dirt or the like		
2		O		Related to internal wirings	• Visual check of cables for damage • Visual check of the cable clamp fixing bolts for the coating of paint • Visual check for cable covers for damage		
			O		• Refasten the fixing bolts, and then apply a coating of paint lock to them.		
3		O		Major bolts	• Visual check of the coating of paint		
			O		• Refasten the fixing bolts, and then apply a coating of paint lock to them.		
4			O	Limit switch dogs	• Activate and deactivate the limit switch to check them for functions. • Refasten the fixing bolts, and then apply a coating of paint lock to them.	E0065 occurs	option
5	O			Motors	• Check for abnormal heat generation. • Check for any abnormal sounds.		
6			O	Brakes	• Set the brake release switch (option) to ON and OFF to check it for operation. **Note**: When setting the brake release switch to ON, the robot arm or the operating axis will drop. Consequently, to check the switch for the operation, set it back to "OFF" within one second.	With the brake release switch set to "OFF", the arm or the end effector does not drop.	Motors with a brake for all axes
Related to J1, J2, and J3 axes							
7	O			Reduction gears	• Check by hearing for any abnormal sounds • Visual check for any vibration or shaking		
			O	Grease in reduction gears	• Checking the density of steel dust in the grease	Less than 0.1 %	J2,J3 axis
Related to J4, J5, and J6 axes							
8		O		Reduction gears	• Check by hearing for any abnormal sounds • Visual check for any vibration or shaking		
9		O		End effector fixing bolts	• Visual check of the fixing bolts for paint coating conditions		
			O		• Refasten the fixing bolts, and then apply a coating of paint lock to them.	Fastening torque: 67 N·m	
10		O		Backlash and play	• Apply loads to each axis in the forward and reverse rotating directions to check it for any backlash and play.	No backlash or play to be felt by hand.	

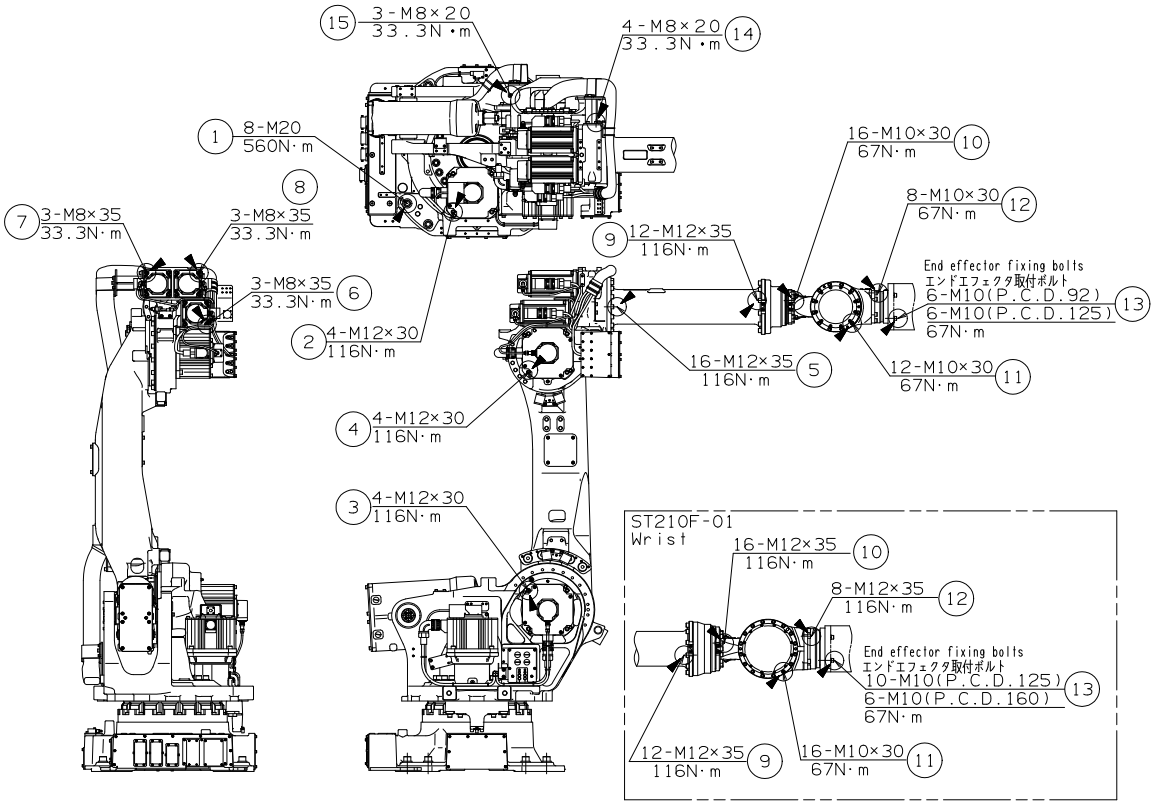
3.2 Inspection of major bolts

CAUTION

Be sure to use a torque wrench to fasten the bolts to proper torque that is shown in the figure below, and then apply a coating of paint lock to them. Furthermore, be careful not to needlessly refasten bolts that are not unfastened.

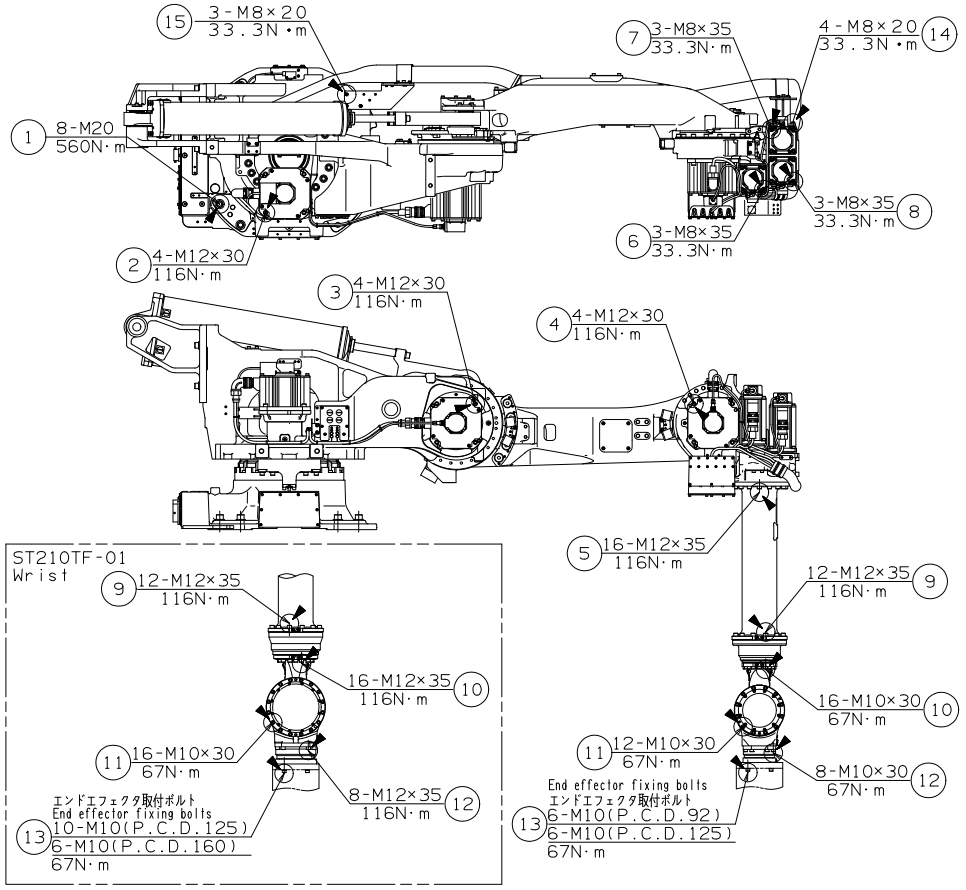
[ST133F-01] [ST166F-01] [ST210F-01]

No.	Inspection point	No.	Inspection point
1	Used to fix the robot	9	Used to fix the J4-axis reduction gear.
2	Used to fix the J1-axis motor.	10	Used to fix the wrist.
3	Used to fix the J2-axis motor.	11	Used to fix the J5-axis reduction gear.
4	Used to fix the J3-axis motor.	12	Used to fix the J6-axis reduction gear.
5	Used to fix the forearm.	13	Used to fix the end effector.
6	Used to fix the J6-axis motor.	14	Used to fix the internal wiring bracket.
7	Used to fix the J5-axis motor.	15	Used to fix the internal wiring bracket.
8	Used to fix the J4-axis motor.		



[ST133TF-01] [ST166TF-01] [ST210TF-01]

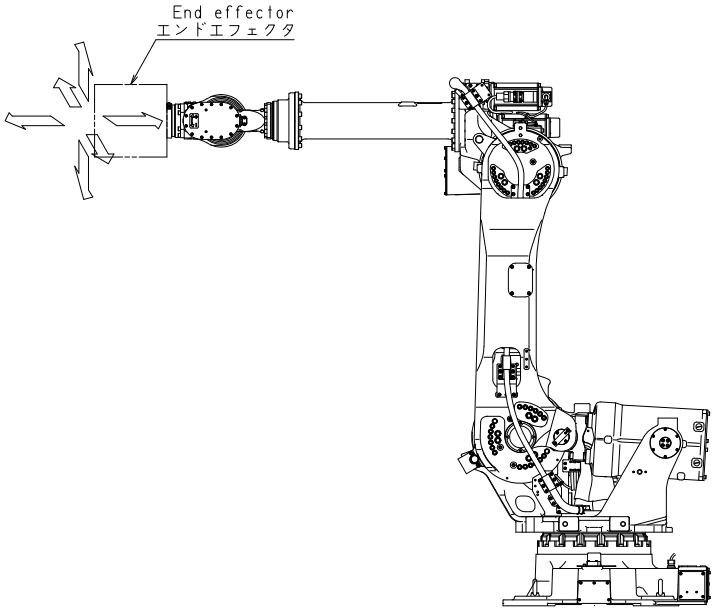
No.	Inspection point	No.	Inspection point
1	Used to fix the robot	9	Used to fix the J4-axis reduction gear.
2	Used to fix the J1-axis motor.	10	Used to fix the wrist.
3	Used to fix the J2-axis motor.	11	Used to fix the J5-axis reduction gear.
4	Used to fix the J3-axis motor.	12	Used to fix the J6-axis reduction gear.
5	Used to fix the forearm.	13	Used to fix the end effector.
6	Used to fix the J6-axis motor.	14	Used to fix the internal wiring bracket.
7	Used to fix the J5-axis motor.	15	Used to fix the internal wiring bracket.
8	Used to fix the J4-axis motor.		



3.3 Inspection of wrist

Apply loads to the end effecter (e.g. a spot gun or hand unit) mounted to the wrist tip in the forward/backward, right/left, and upward/downward, and then check it for any backlash and play felt by hand.

[ST133F-01] [ST166F-01] [ST210F-01]



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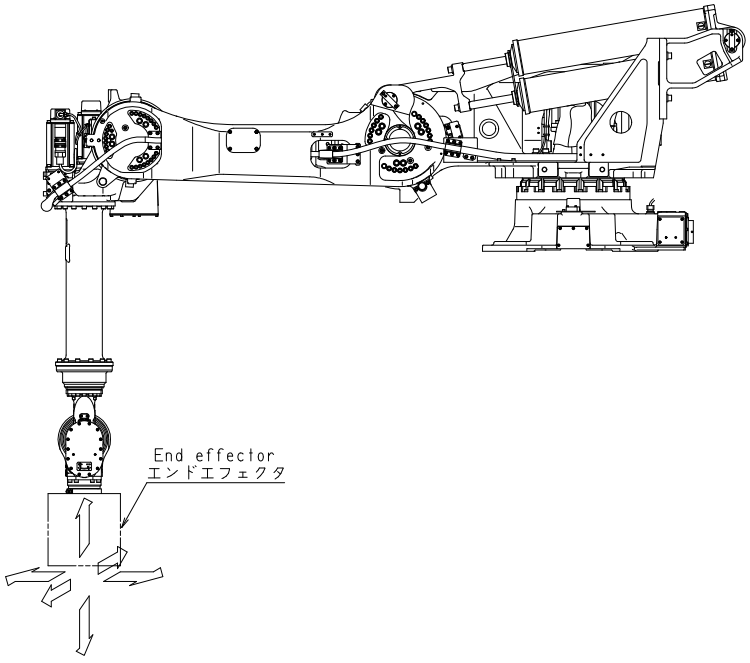


3.4 Inspection of wirings

CAUTION

Flex resisting cables are used for the internal wirings for the robot. However, if the cables are broken or short-circuited due to damage or crushes, the robot will malfunction. To avoid that, **perform thorough daily inspections**.

CAUTION

If any part is damaged, immediately repair or replace the part.

CAUTION

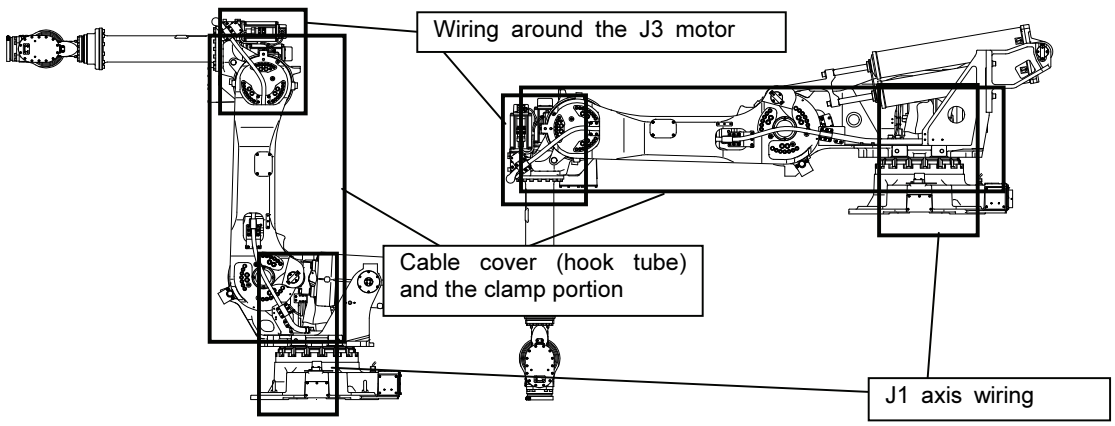
To purchase any manipulator wiring, contact to your local service center. NEVER attempt to use any cables other than specified by NACHI.
For the replacement, order to your local service center.

CAUTION

Do not apply external force or connect other cables to the external cables of the robot.

Check the portions shown in the figure below for any damage to cables, hoses, or covers, referring to the following each procedure. **If any part is damaged, immediately repair or replace the part**. Furthermore, if the clamp part is loose, refasten it.
If the cables or else are needed to replace, contact our Service Center.

[ST133F-01] [ST166F-01] [ST210F-01] **[ST133TF-01] [ST166TF-01] [ST210TF-01]**



Inspection points: Cables cover (hook tube) and clamp portion

There are some inspection locations where the cable covers (silver cover) and the hook tube (gray cover) is used to cover the wires with double covering. Hook tube is maintenance parts used to prevent from rubbing of wires at the moving portion.
Please refer to “Chapter 4.4 Wiring cover replacement” for the detail of it.

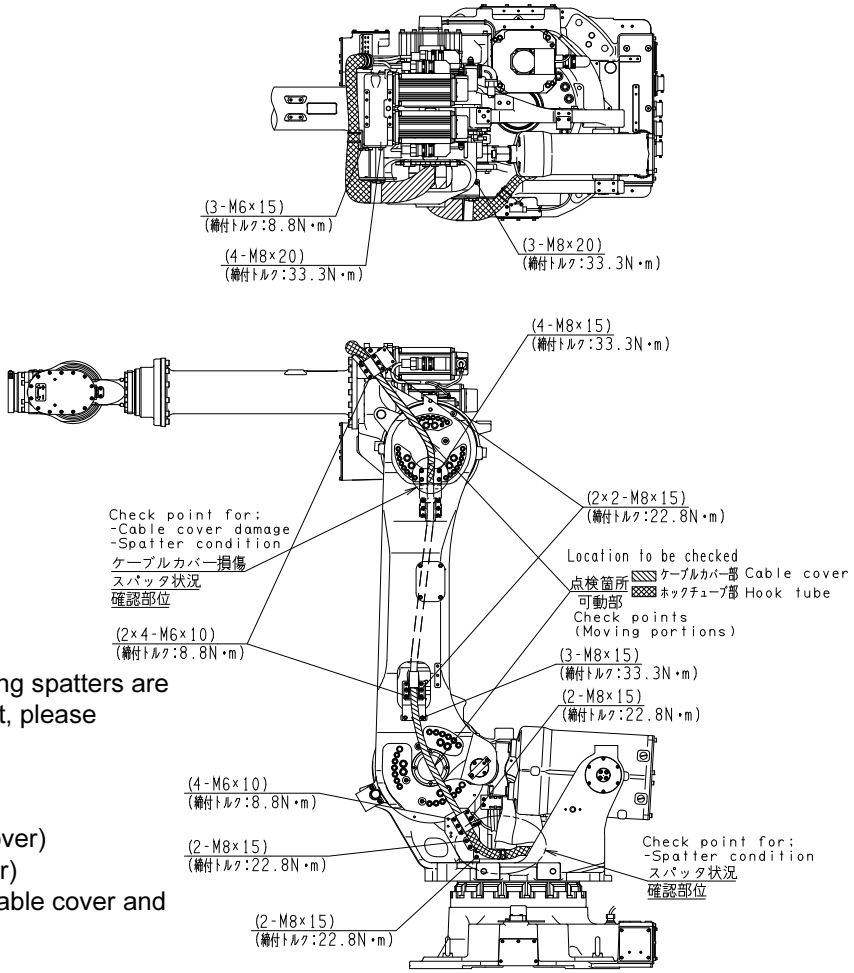
Check for the following items.

- Whether or not any cable cover has holes and fractures. And whether or not the damage of hook tube reaches to the level to be replaced with new one. (*)
- Whether or not the cable cover fastening part is loosed. (*)
- Whether or not the clamp bolt of the spring gets unfastened or comes off.

(*) When checking or replacing the cover, please pay special attention not to let any dusts get into the inside part of the cover.

- If damage to the cover is observed, replace it. If the cover is not closed, close (fasten) the cover.If any unfastened bolt is observed, refasten the bolt to the specified torque, and then put marking on it. The M6 bolts and the M8 bolts are used.

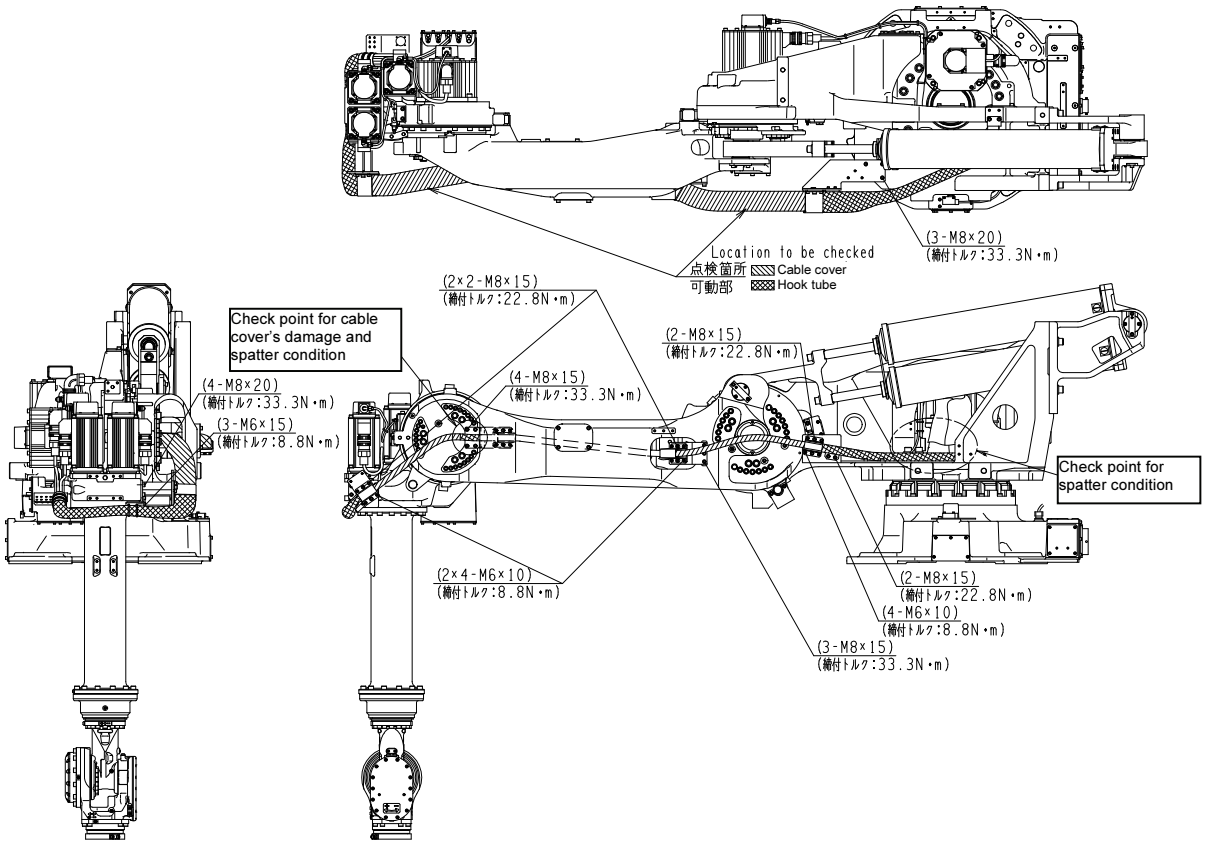
[ST133F-01] [ST166F-01] [ST210F-01]



Furthermore, if any welding spatters are found in the following part, please remove them.

- bracket
- fixing bolt
- cable cover (silver cover)
- hook tube (gray cover)
- clearance between cable cover and hook tube

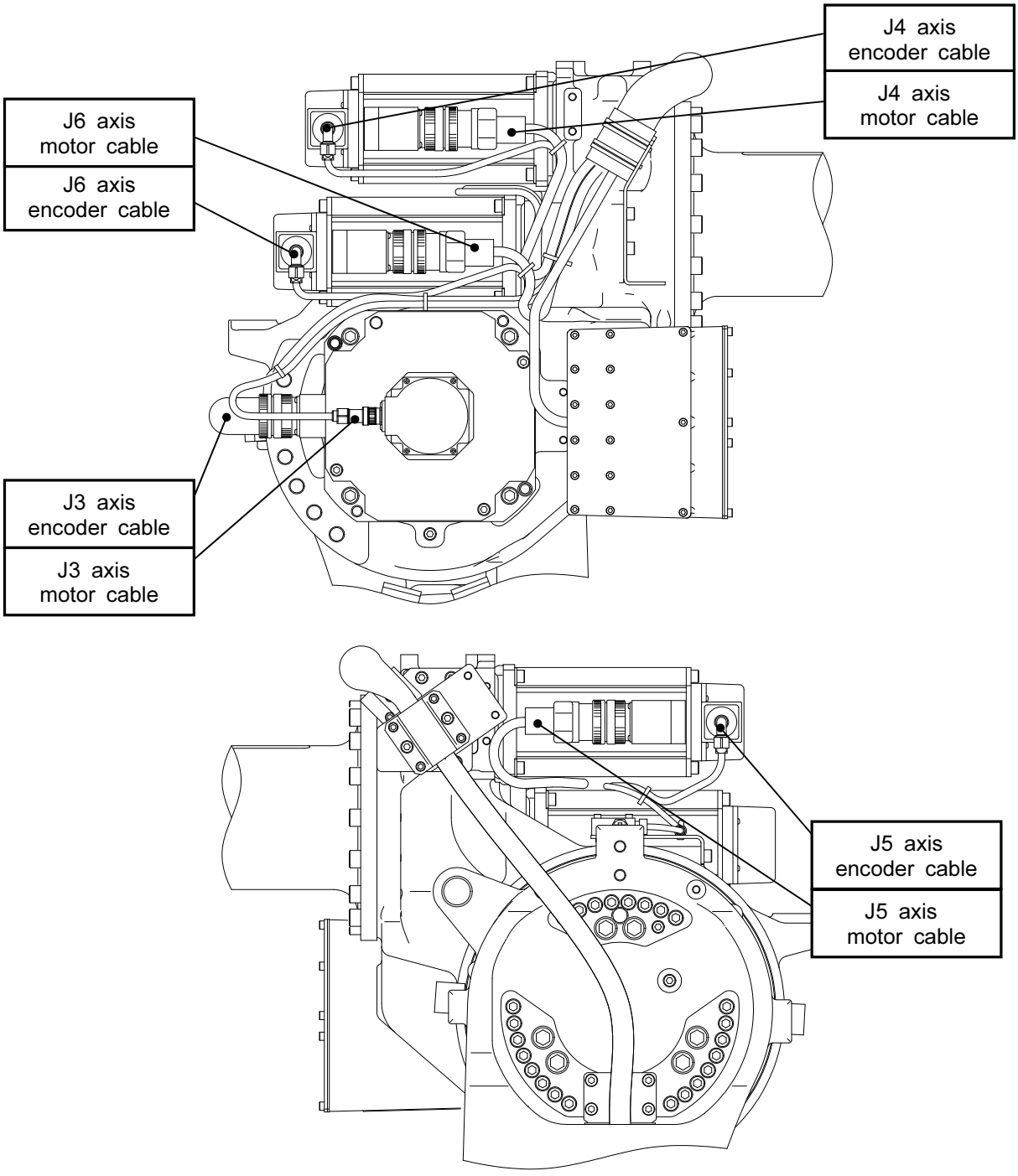
[ST133TF-01] [ST166TF-01] [ST210TF-01]



Inspection points : Wiring around the J3 motor

Check for the following items.

- Whether or not any cable sharply bends over or gets crushed.
- Whether or not any cable shield has scratches or fractures.
- Whether or not any hose surface has scratches or fractures.
- Whether or not any hose and cable has welding spatters or singes.
- Whether or not any cable tie is broken.



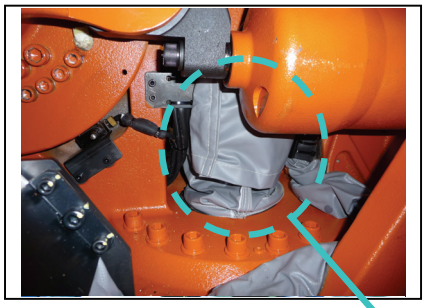
Inspection points : Wiring around the J1 motor

Open the wiring cover at the center of the frame from the lower side and visually inspect the wiring inside the cover.

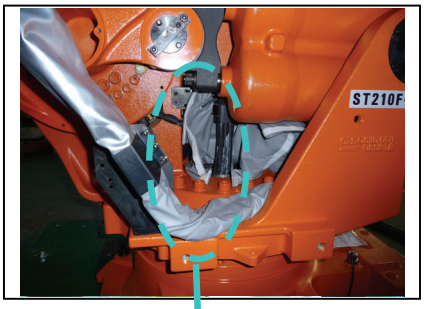
Check for the items below;

- Whether or not any cable cover has scratches or fractures.
- Whether or not the clamp bolt of the spring gets unfastened or comes off.

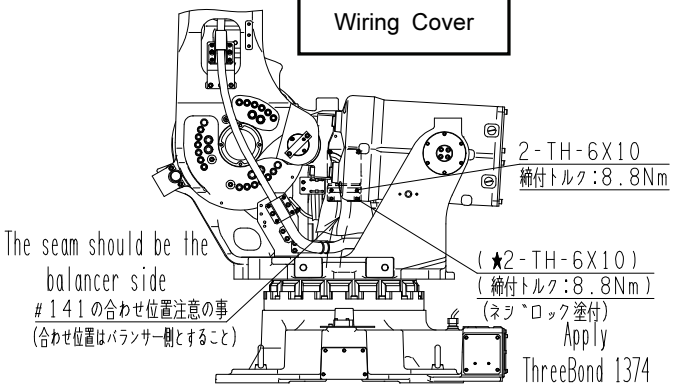
After inspection, re-fasten(close) the cable cover.

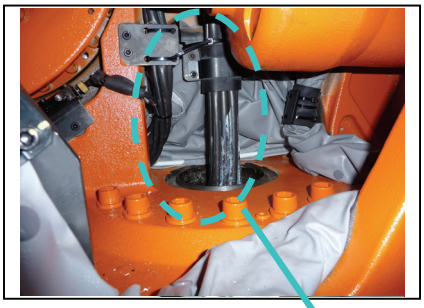


Open the cover from the lower side



Wiring Cover





Inspection location

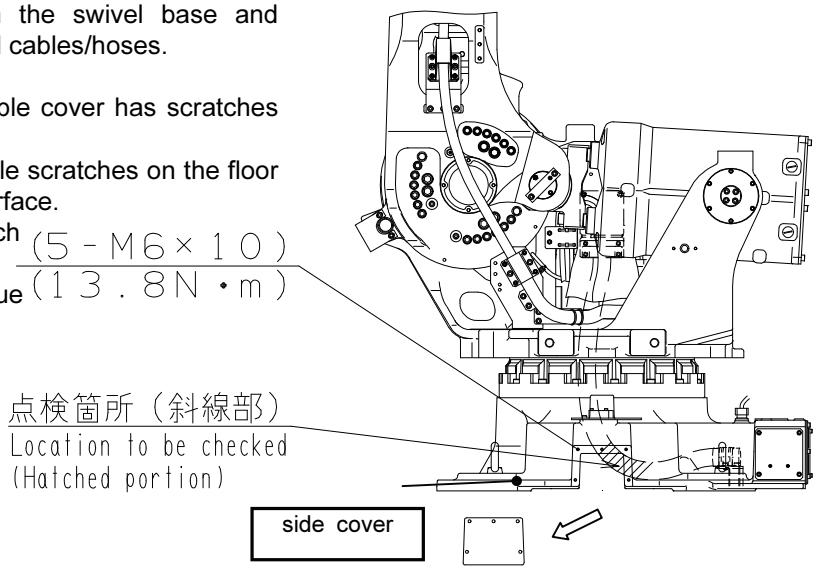
Inspection points : Wiring around the J1 motor

Open the side cover on the swivel base and visually inspect the internal cables/hoses.

Check for the items below;

- Whether or not any cable cover has scratches or fractures.
- Whether or not any cable scratches on the floor or the installation plate's surface.

After the inspection, re-attach the cover and tighten the fixing bolts at specified torque and apply marking on them.



3.5 Inspection of grease

Please check the density of steel dust in the grease of reduction gear every 5,000 hours or every 1 year (in case of material handling application, every 2,500 hours or every half year).
If the measurement result exceeds this value, please contact our service center for grease replacement or reduction gear replacement.

Required tools

- Grease steel dust meter
  Recommended grease steel dust meter OM-810 (Idemitsu Kosan Ltd.)
- Grease gun (Lubrication amount counter function, A nozzle of less than 17 mm in diameter.)
- Seal tape

[ST133F-01] [ST166F-01] [ST210F-01]
[ST133TF-01] [ST166TF-01] [ST210TF-01]

No.	Inspection points	Grease type	Inspection amount	Purpose	Type	Size	Tightening torque	Criterion of steel dust
1	J2 axis Reduction gear	MOLYWHITE RE No.00	10 cc	Air release	Plug	Rc-1/8	12.7 N·m	less than 0.1 %
				Discharge	Plug	Rc-1/4	29.4 N·m	
2	J3 axis Reduction gear	MOLYWHITE RE No.00	10 cc	Air release	Plug	Rc-1/4	29.4 N·m	
				Discharge	Plug	Rc-1/4	29.4 N·m	

Density of grease : MOLYWHITE RE No.00 (Nabtesco) 0.87g/cc

<Note>

- In order to prevent the grease from splashing out (this is caused by e.g. rising of internal pressure or internal temperature), unplug the air release plug shown below in advance. When releasing the plug, loosen the plug slowly to release the remaining pressure slowly.
- After the completion of inspection, wipe grease running out from the lubrication port. Then, wind sealing tape around the threaded part of the socket head plug to prevent the leakage of grease, and plug it again.

CAUTION

If the grease leaks out too much when inspecting the steel dust density, lubricate grease using a grease gun. For lubrication, use a grease gun with a nozzle of less than 17 mm in diameter. Note that lubricating grease more than the recommended amount may result in leakage of grease or faulty robot locus.

After the completion of lubrication, in order to prevent the leakage of grease, be sure to wind sealing tape around the grease nipples and socket head plug.

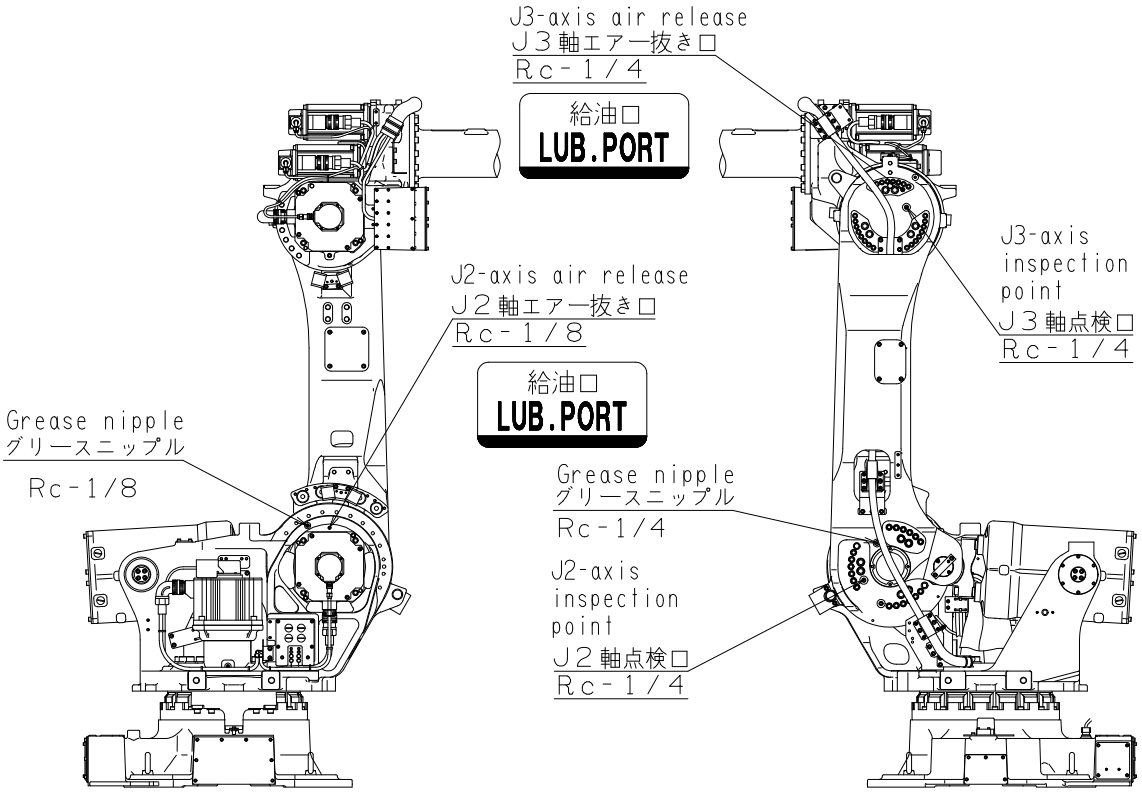
CAUTION

A grease gun that has a capacity to measure the lubrication amount is recommended. If a grease gun like this can not be prepared, please measure the weight of the grease can before/after the lubrication work to confirm the amount.

CAUTION

Immediately after removing the drain plug, grease may splash, because internal pressure is still high, for example soon after robot stops,

[ST133F-01][ST166F-01][ST210F-01]



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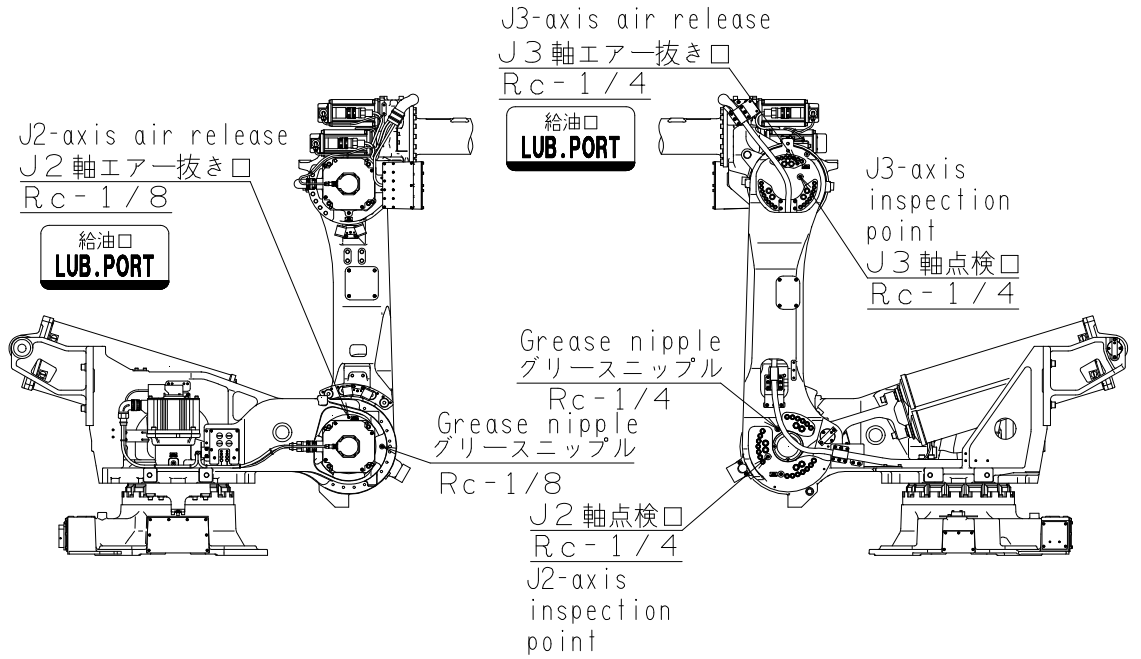


Chapter 4 Maintenance

Maintenance and inspection

WARNING

The maintenance and inspection of the robot must be performed by personnel who received special instructor education or education for a period of hours provided by law and further really knows how to perform the maintenance and inspection on the robot.

WARNING

To perform the maintenance and inspection, be sure to check for safety around the robot and ensure safe corridors and shelters to escape from hazardous situations.

WARNING

To perform daily inspection, repair, or part replacement of the robot, be sure to turn OFF the power supply. Furthermore, in order to prevent other workers from improperly turning ON the power supply, post the warning signs such as “DON’T POWER ON” at the primary power supply switch and others.

WARNING

To replace any parts, be sure to use specified parts.
For details, refer to information in the “List of Maintenance Parts” of the “AX Controller Maintenance Manual” and the “Recommended Spare Parts” of the “Robot Maintenance Manual”.

WARNING

To perform the maintenance and inspection, if hazardous situations are induced by the drop or move of the robot arm, be sure to lock the arm.
For details, refer to information in the “Motor replacement” section in the “Trouble shooting” in the “Service Maintenance Manual” for the robot.

DANGER

The balance spring device is internally compressed even in the normal state. Never attempt to dismount or disassemble this device. Otherwise it will result in a highly hazardous situation.

4.1 Lubrication

Lubricate the mechanical sections of the robot with grease not only when insufficient grease is observed by checking but also at regular intervals of time.

CAUTION

For lubrication, use a grease gun with a nozzle of not more than 17 mm in diameter. Furthermore, for lubrication points with an air vent hole specified, unplug the plug according to the figures, and then lubricate them.

CAUTION

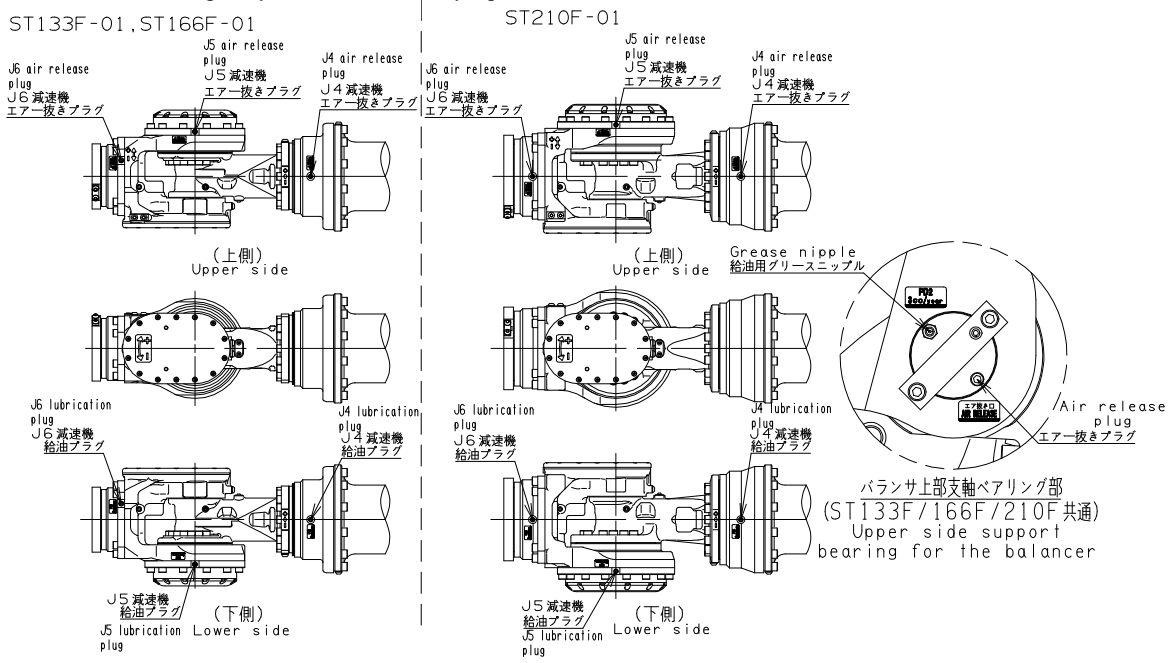
Note that lubricating grease more than the recommended amount may result in leakage of grease or faulty robot locus.
Furthermore, no lubrication is required for any points other than those specified.

[ST133F-01][ST166F-01][ST210F-01]

No.	Lubrication point	Lubrication port	Lubrication frequency	Applicable Grease	Lubrication amount	Remark
1	Roller bearing of upper balancer spindle	Upper balancer fulcrum	Every 12 months	Long Time PD2	3^{+1}_{0} cc	*1
2	J4-axis reduction gear	Lower part of forearm on the front side	Every 12 months	〃	3^{+1}_{0} cc	*1, *2
3	J5-axis reduction gear	Lower part of the wrist unit	Every 12 months	〃	3^{+1}_{0} cc	*1, *2
4	J6-axis reduction gear	Lower part of the wrist unit	Every 12 months	〃	3^{+1}_{0} cc	*1, *2

*1 In order to prevent the internal pressure from rising due to pressure caused by the lubrication, unplug the air vent plug shown in the following figure. If the pressure caused by the lubrication is applied to the oil seal part, leakage of grease will result.
After the completion of lubrication, wipe grease running out from the lubrication port. Then, wind sealing tape around the threaded part of the socket head plug to prevent the leakage of grease, and plug it again.

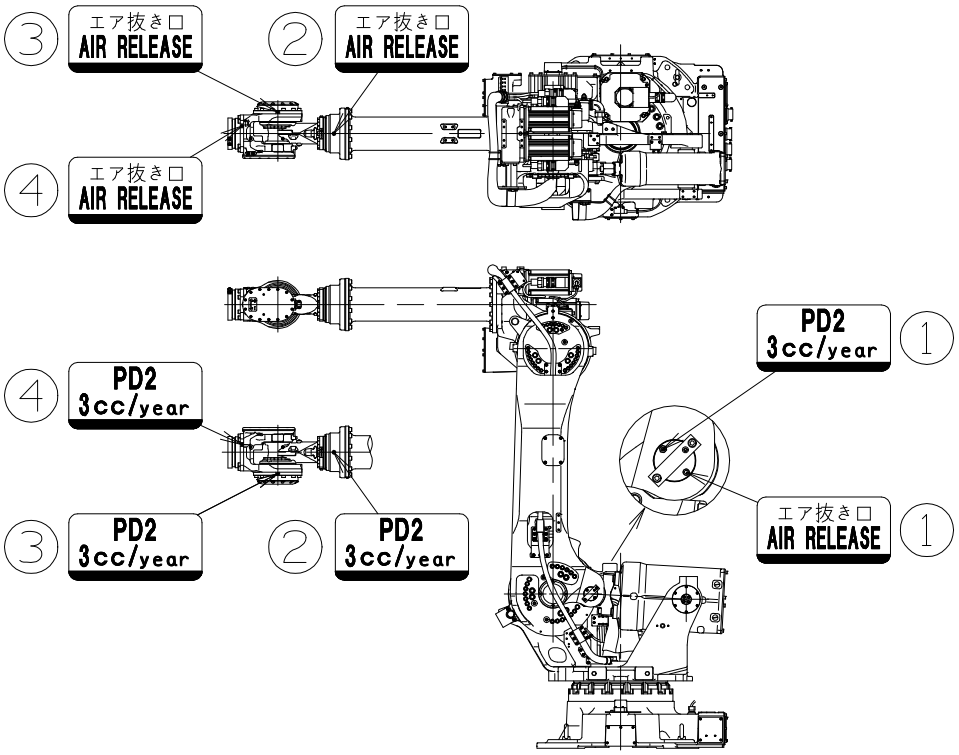
Fastening torque of socket head plug: PT1/8 12.7 N·m



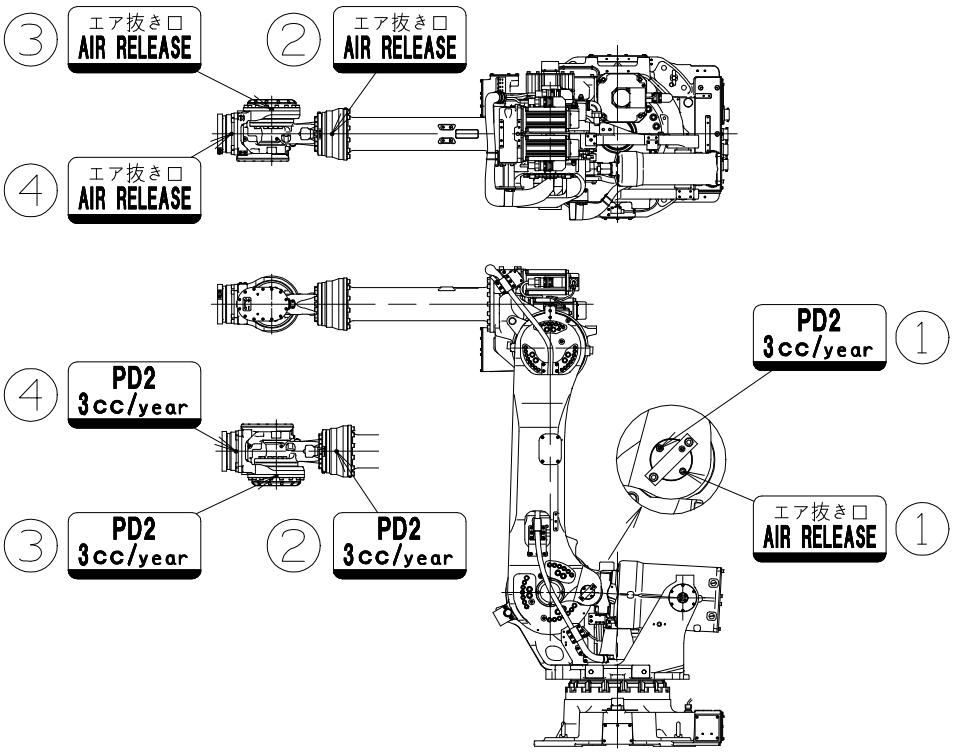
*2 Unplug the socket head plug, and then mount a grease nipple (refer to "4.2 Grease replacement") that is mounted to the frame to lubricate the points. After the completion of lubrication, wind sealing tape around the threaded part of the socket head plug to prevent the leakage of grease, and plug it again.

Fastening torque of socket head plug: PT1/8 12.7 N·m

[ST133F-01] [ST166F-01]



[ST210F-01]



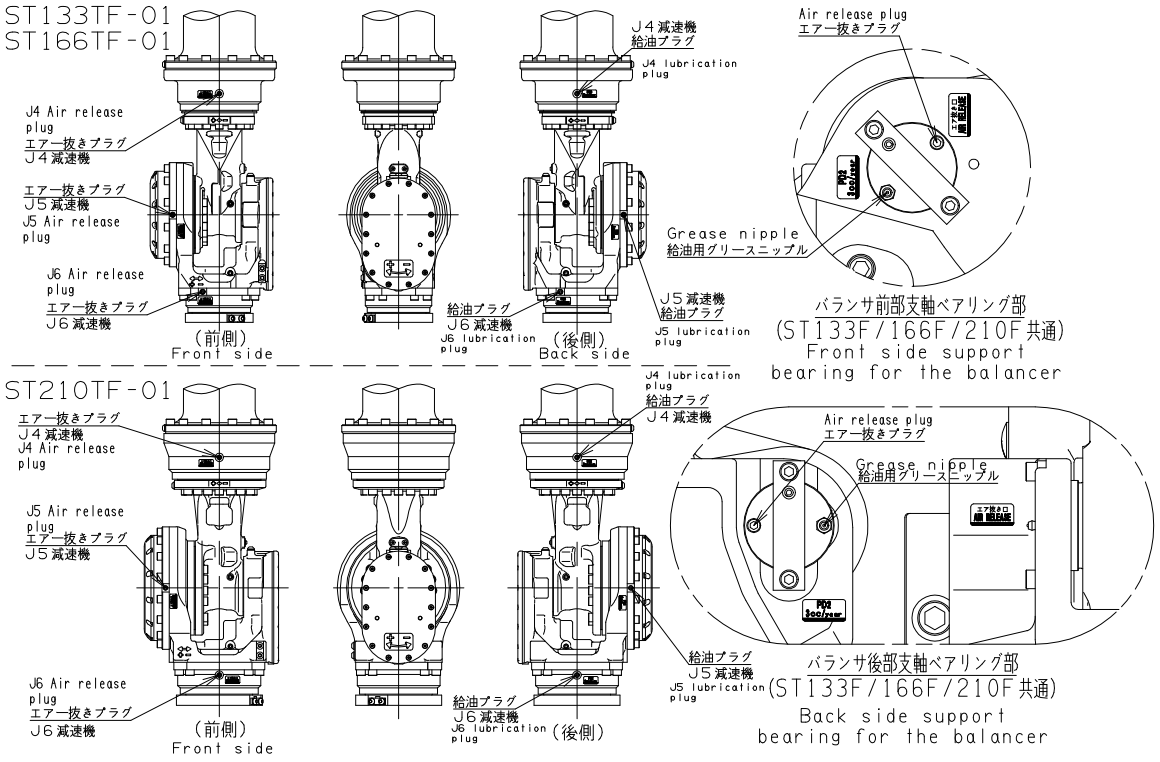
[ST133TF-01][ST166TF-01][ST210TF-01]

[Table 4.1-2] Grease lubrication points

No.	Lubrication point	Lubrication port	Lubrication frequency	Applicable Grease	Lubrication amount	Remark
1	Balancer support bearing (Front side)	Balancer support axis (Front side)	Every 12 months	Long Time PD2	3^{+1}_{0} cc	*1
2	Balancer support bearing (Back side)	Balancer support axis (Back side)	Every 12 months	〃	3^{+1}_{0} cc	*1
3	J4-axis reduction gear	Lower part of forearm on the front side	Every 12 months	〃	3^{+1}_{0} cc	*1, *2
4	J5-axis reduction gear	Rear of the wrist unit	Every 12 months	〃	3^{+1}_{0} cc	*1, *2
5	J6-axis reduction gear	Rear of the wrist unit	Every 12 months	〃	3^{+1}_{0} cc	*1, *2

*1 In order to prevent the internal pressure from rising due to pressure caused by the lubrication, unplug the air vent plug shown in the following figure. If the pressure caused by the lubrication is applied to the oil seal part, leakage of grease will result.
After the completion of lubrication, wipe grease running out from the lubrication port. Then, wind sealing tape around the threaded part of the socket head plug to prevent the leakage of grease, and plug it again.

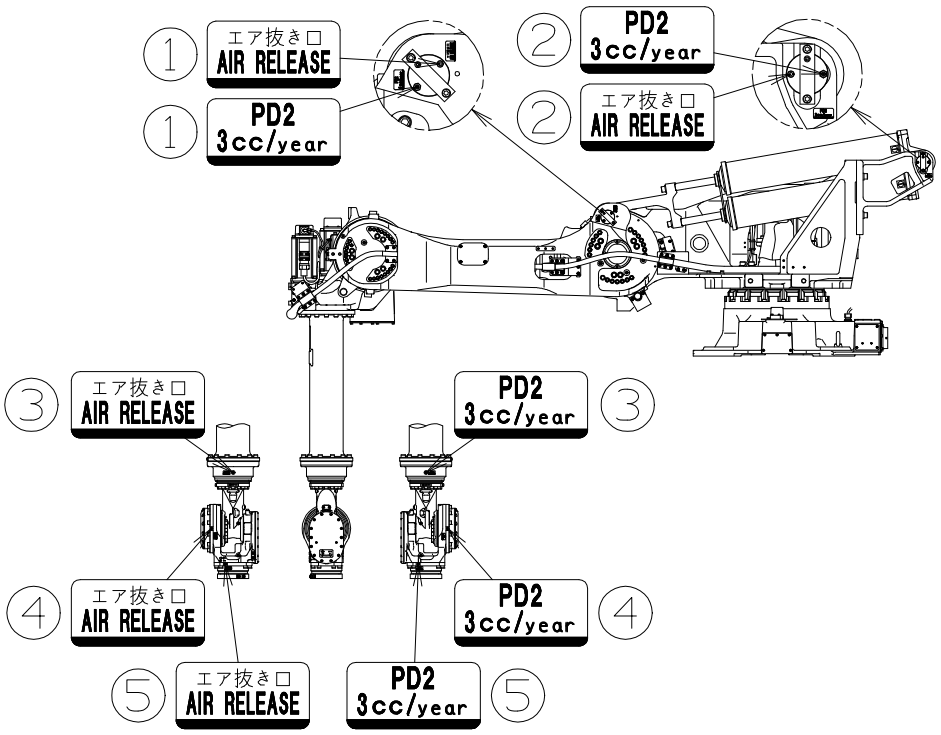
Fastening torque of socket head plug: PT1/8 12.7 N·m



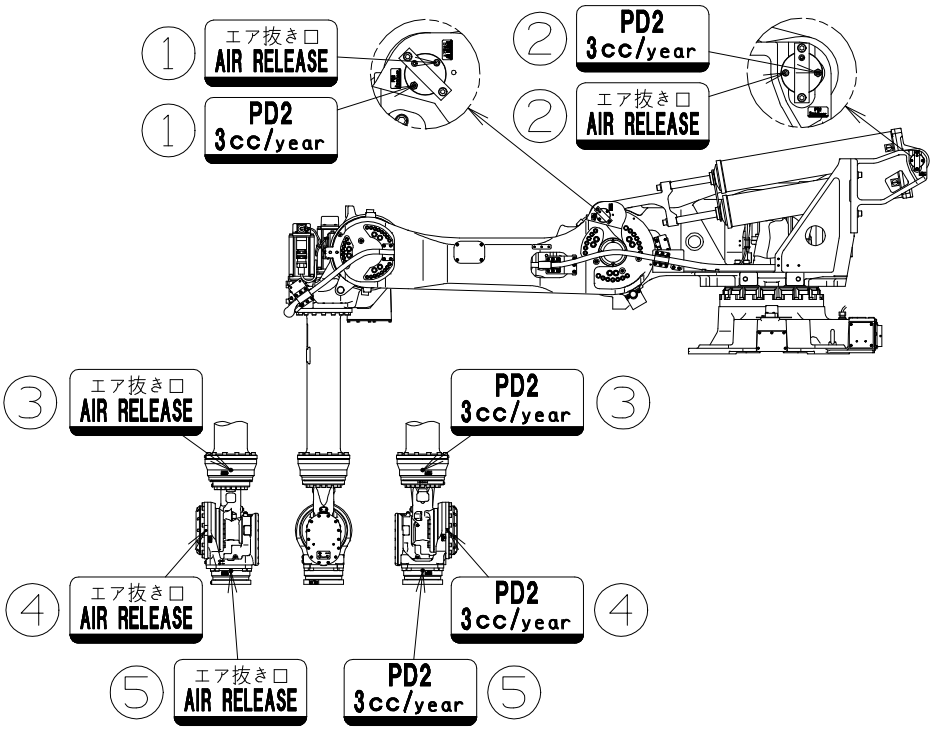
*2 Unplug the socket head plug, and then mount a grease nipple (refer to "4.2 Grease replacement") that is mounted to the frame to lubricate the points. After the completion of lubrication, wind sealing tape around the threaded part of the socket head plug to prevent the leakage of grease, and plug it again.

Fastening torque of socket head plug: PT1/8 12.7 N·m

[ST133TF-01][ST166TF-01]



[ST210TF-01]



4.2 Grease replacement

Please replace grease every 20,000 operating hours or every 4 years (If the application type is material handling, every 10,000 operating hours or every 2 years).

[ST133F-01] [ST166F-01] [ST210F-01][ST133TF-01] [ST166TF-01] [ST210TF-01]

[Table 4.2-1] Grease replacement points

No.	Replacement point	Applicable grease	Lubrication amount	Application	Lubrication port	Size	Fastening torque	Remark
1	J1-axis reduction gear	MOLYWHITE RE No. 00	More than 3400 cc	Lubrication	Plug	Rc-1/8	12.7 N·m	If a grease lubrication is done rapidly, the oil seal may be broken and grease leakage may occur because of a rise of the pressure inside the grease bus inside the robot The lubrication speed should be ***40cc/10 [sec]*** or less.
				Drain	Plug	Rc-1/4	29.4 N·m	
2	J2-axis reduction gear	〃	More than 1500 cc	Lubrication	Plug	Rc-1/8	12.7 N·m	
				Drain	Plug	Rc-1/4	29.4 N·m	
3	J3-axis reduction gear	〃	More than 1000 cc	Lubrication	Plug	Rc-1/4	29.4 N·m	
				Drain	Plug	Rc-1/4	29.4 N·m	

Density of grease : MOLYWHITE RE No.00 0.87g/cc

Required tools etc.

- Grease gun (with lubrication amount counter function)
- Lubrication connector [Rc-1/8,φ8] (1)
- Drain connector [φ12X9 0.2m] (1)
- Air precision regulator (1)
  (MAX 0.2Mpa and adjustable every approx. 0.01Mpa)
- Air supply source
- Weight meter that can measure the weight of the (ejected grease + container)
- Seal tape

CAUTION

For lubrication, use a grease gun with a nozzle of not more than 17 mm in diameter. Note that lubricating grease more than the recommended amount may result in leakage of grease or faulty robot locus.

After the completion of lubrication, in order to prevent the leakage of grease, be sure to wind sealing tape around the grease nipples and socket head plug.

CAUTION

A grease gun that has a capacity to measure the lubrication amount is recommended. If a grease gun like this can not be prepared, please measure the weight of the grease can before/after the lubrication work to confirm the amount.

CAUTION

Immediately after removing the drain plug, grease may splash, because internal pressure is still high, for example soon after robot stops,

[ST133F-01] [ST166F-01] [ST210F-01][ST133TF-01] [ST166TF-01] [ST210TF-01]

[Table 4.2-2] Robot pose for grease replacement

Replacing portion	J1	J2	J3	J4,J5,J6
J1 axis reduction gear	-90°	any	any	any
J2 axis reduction gear	any	90°		
J3 axis reduction gear		90°	0°	
Another portion		90°	0°	

[ST133F-01] [ST166F-01] [ST210F-01]

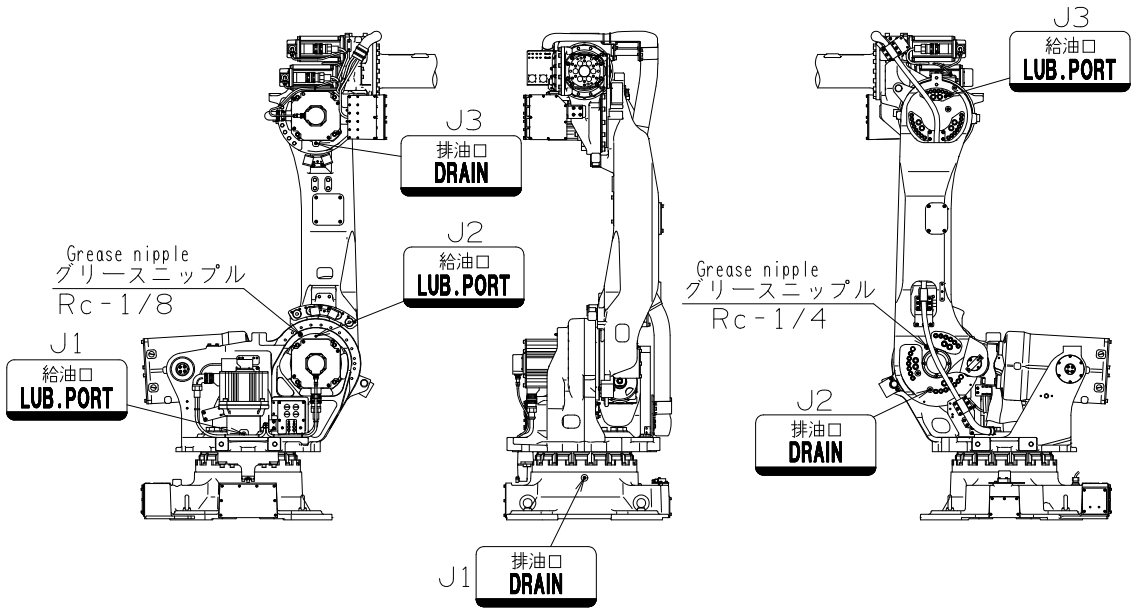


Fig.4.2-1 Grease replacement portions

[ST133TF-01][ST166TF-01][ST210TF-01]

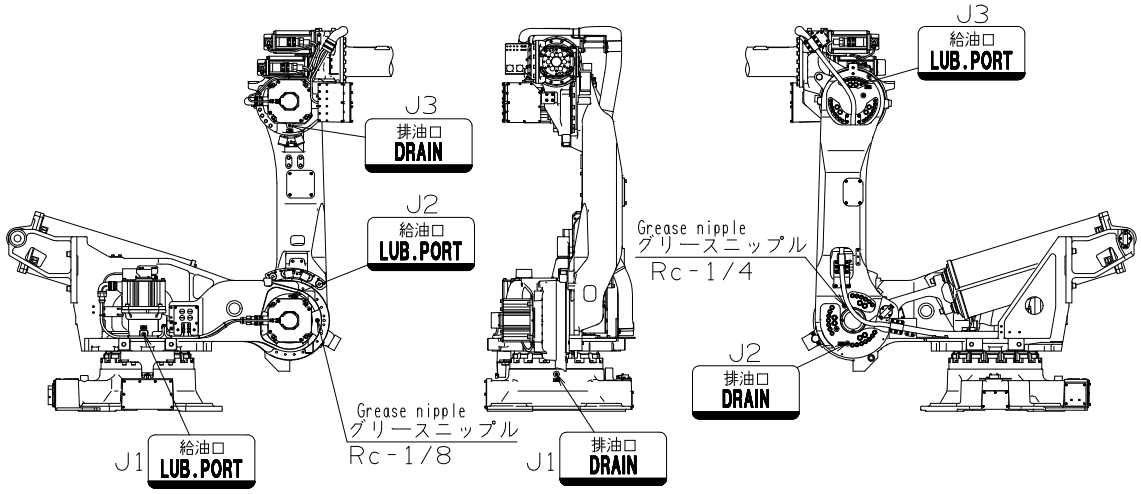


Fig.4.2-2 Grease replacement portions

Grease replacement procedure of J1 axis reduction gear

(1) Place a container to receive grease ejected under the ejection outlet. In advance, confirm the weight of the container.
(2) Unplug the socket head plug [Rc-1/4] from the ejection outlet. To prevent the robot from getting dirty, attach a drain connector [Rc-1/4, φ12] and a drain tube [φ12×9, maximum length is 0.2m] (Fig.4.2-3)
(3) Unplug the socket head plug [Rc-1/8] from the inlet, and attach the grease nipple [Rc-1/8]
(4) Use a grease gun to feed grease. At this time, grease feeding operation must be done ***keeping the feeding speed to 40cc per 10 seconds or less.*** The amount of the grease to be lubricated is shown in the [Table 4.2-1]. Keep the feeding operation until the color of the grease that is pushed out from the ejection outlet change to a color of new grease.
(5) When the lubricated (fed) amount reaches the values shown in the Table4.2, confirm the ***(a):lubricated amount*** and the ***(b):ejected amount***. (a) can be calculated by comparing the grease can's weight before and after the lubrication work or checking the counter display on the grease gun. (b) can be calculated by measuring the weight of the container.
(6) If (a) is larger than (b), too much (surplus) grease remains inside the gear box. To make (a) and (b) the same, use air to push the grease out. Supply air from the lubrication inlet and eject the surplus grease from the ejection outlet. Be sure that the air pressure should be kept ***under 0.025Mpa by using precise regulator.*** (See Fig.4.2-4)
If only air comes out from the ejection outlet and grease does not come out, move the J1 axis while supplying air referring to the Fig.4.2-5 to push the grease out.
(7) If (a) is less than (b), grease is lacked inside the gear box. To make (a) and (b) the same, swap the inlet and outlet, and supply the lacked amount of grease from the ejection outlet.
(8) Wrap seal tapes on socket head plug [Rc-1/8] and attach to the inlet (LUB.PORT).
Wrap seal tapes on socket head plug [Rc-1/4] and attach to the outlet (DRAIN).

CAUTION

In case that robot operation with slow speed playback or teaching operation is necessary, never get into the robot moving envelope while playback.
And perform above procedure with two persons one pair. One person keeps to be ready to push the emergency button anytime, other person operates the robot paying much attention. Please ensure the escape route in advance.

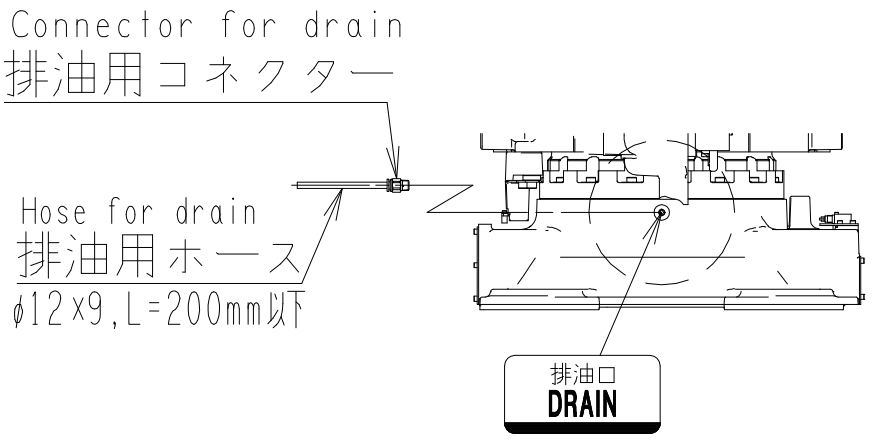


Fig.4.2-3 Connection of drain hose and connector

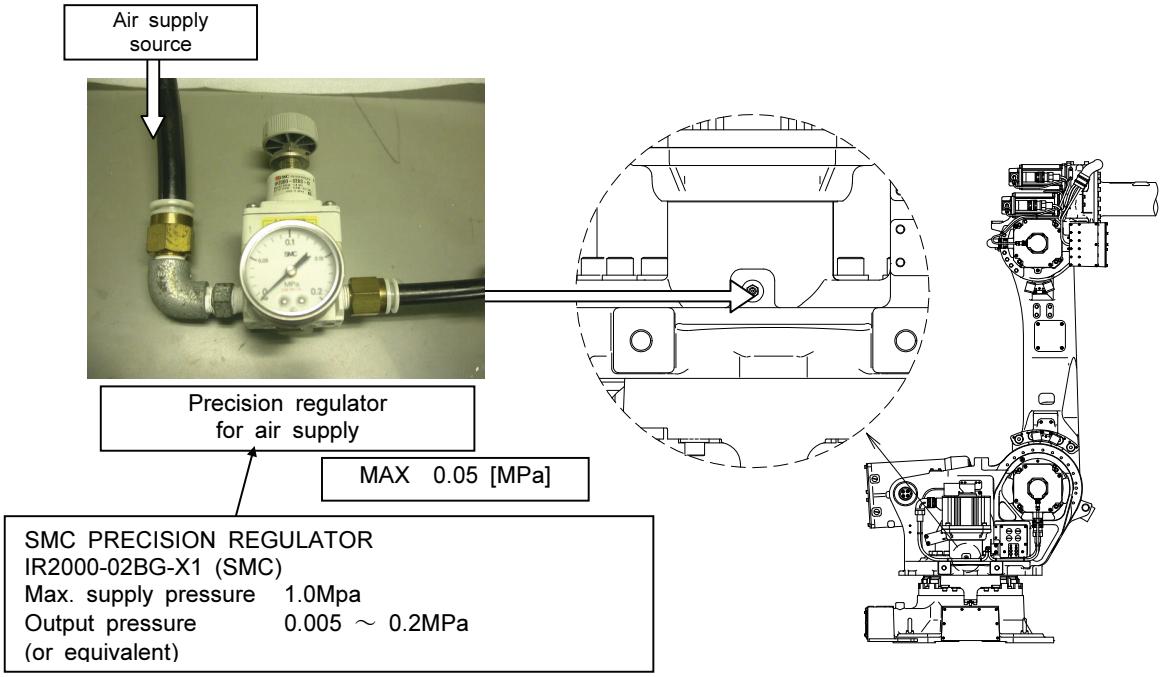


Fig.4.2-4 Pushing out the surplus grease using air pressure

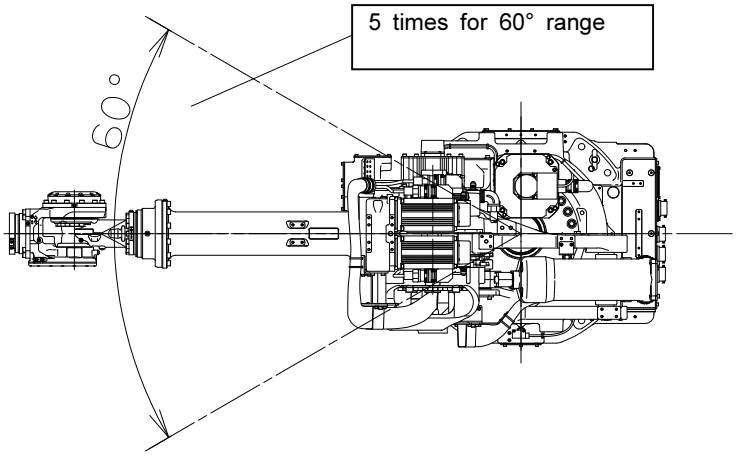


Fig.4.2-5 J1 axis low speed motion range

Grease replacement procedure of J2 axis reduction gear

(1) Place a container to receive grease ejected under the ejection outlet. In advance, confirm the weight of the container.
(2) Unplug the socket head plug [Rc-1/4] from the ejection outlet. To prevent the robot from getting dirty, attach a drain connector [Rc-1/4, φ12] and a drain tube [φ12×9, maximum length is 0.2m] (Fig.4.2-6, Fig 4.2-7)
(3) Unplug the socket head plug [Rc-1/8] from the inlet, and attach the grease nipple [Rc-1/8]
(4) Use a grease gun to feed grease. At this time, grease feeding operation must be done ***keeping the feeding speed to 40cc per 10 seconds.*** The amount of the grease to be lubricated is shown in the Table 4.2-1. Keep the feeding operation until the color of the grease that is pushed out from the ejection outlet change to a color of new grease.
(5) When the lubricated (fed) amount reaches the values shown in the Table4.2, confirm the ***(a):lubricated amount*** and the ***(b):ejected amount***. (a) can be calculated by comparing the grease can's weight before and after the lubrication work or checking the counter display on the grease gun. (b) can be calculated by measuring the weight of the container(for this calculation, please check the weight of the empty container measured in step (1) in advance).
(6) If (a) is larger than (b), too much (surplus) grease remains inside the gear box. To make (a) and (b) the same, use air to push the grease out. Supply air from the lubrication inlet and eject the surplus grease from the ejection outlet. Be sure that the air pressure should be kept ***under 0.025Mpa by using precise regulator.*** (See Fig.4.2-4)
If only air comes out from the ejection outlet and grease does not come out, move the J2 axis while supplying air referring to the Fig.4.2-8,-9 to push the grease out.
(7) If (a) is less than (b), grease is lacked inside the gear box. To make (a) and (b) the same, swap the inlet and outlet, and supply the lacked amount of grease from the ejection outlet.
(8) Wrap seal tapes on socket head plug [Rc-1/8] and attach to the inlet (LUB.PORT).
Wrap seal tapes on socket head plug [Rc-1/4] and attach to the outlet (DRAIN).

[ST133F-01][ST166F-01][ST210F-01]

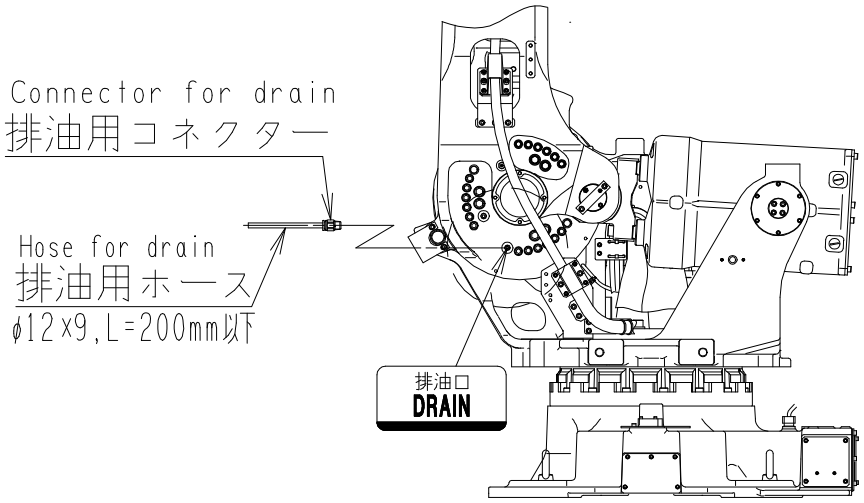


Fig.4.2-6 Connection of drain hose and connector

[ST133TF-01][ST166TF-01][ST210TF-01]

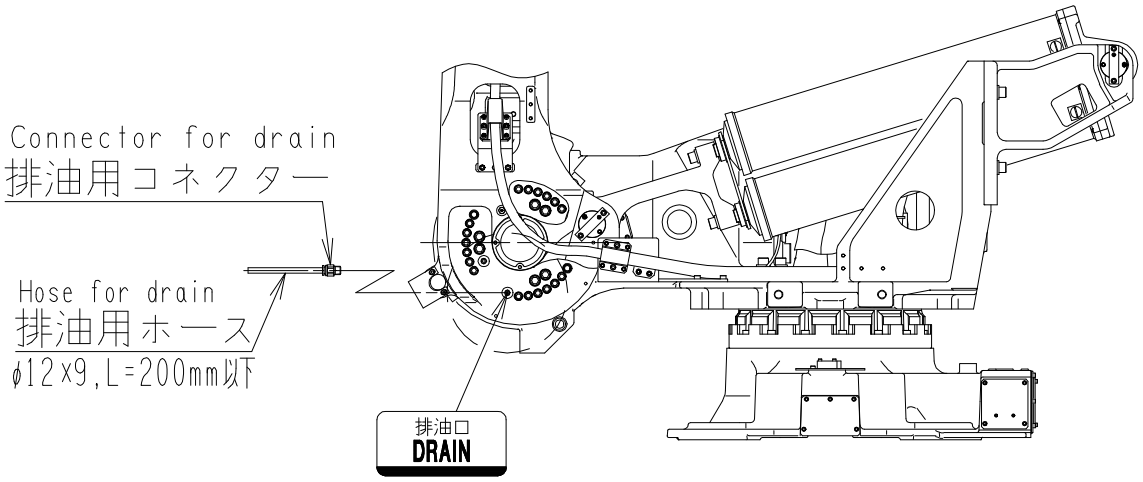


Fig.4.2-7 Connection of drain hose and connector

[ST133F-01][ST166F-01][ST210F-01]

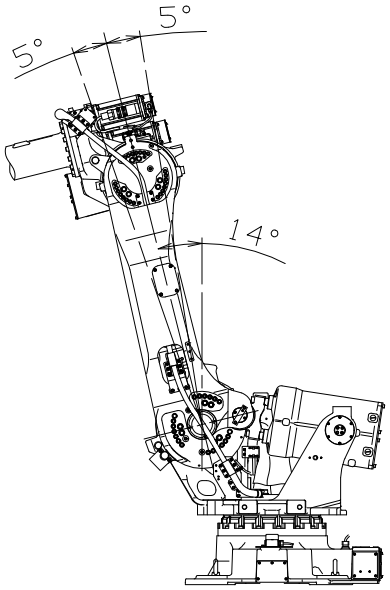


Fig 4.2-8 J2 axis low speed motion range

[ST133TF-01][ST166TF-01][ST210TF-01]

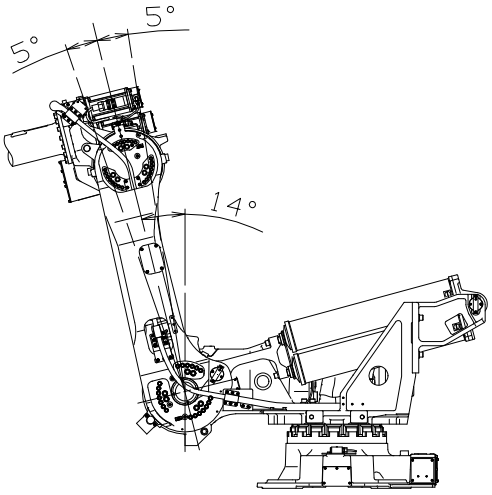


Fig 4.2-9 J2 axis low speed motion range

Grease replacement procedure of J3 axis reduction gear

(1) Place a container to receive grease ejected under the ejection outlet. In advance, confirm the weight of the container.
(2) Unplug the socket head plug [Rc-1/4] from the ejection outlet. To prevent the robot from getting dirty, attach a drain connector [Rc-1/4, φ12] and a drain tube [φ12×9, maximum length is 0.2m] (Fig.4.2-10)
(3) Unplug the socket head plug [Rc-1/4] from the inlet, and attach the grease nipple [Rc-1/4]
(4) Use a grease gun to feed grease. At this time, grease feeding operation must be done ***keeping the feeding speed to 40cc per 10 seconds.*** The amount of the grease to be lubricated is shown in the Table 4.2-1. Keep the feeding operation until the color of the grease that is pushed out from the ejection outlet change to a color of new grease.
(5) When the lubricated (fed) amount reaches the values shown in the Table4.2, confirm the ***(a):lubricated amount*** and the ***(b):ejected amount***. (a) can be calculated by comparing the grease can's weight before and after the lubrication work or checking the counter display on the grease gun. (b) can be calculated by measuring the weight of the container(for this calculation, please check the weight of the empty container measured in step (1) in advance).
(6) If (a) is larger than (b), too much (surplus) grease remains inside the gear box. To make (a) and (b) the same, use air to push the grease out. Supply air from the lubrication inlet and eject the surplus grease from the ejection outlet. Be sure that the air pressure should be kept ***under 0.025Mpa by using precise regulator.*** (See Fig.4.2-4)
If only air comes out from the ejection outlet and grease does not come out, move the J3 axis while supplying air referring to the Fig.4.2-11 to push the grease out.
(7) If (a) is less than (b), grease is lacked inside the gear box. To make (a) and (b) the same, swap the inlet and outlet, and supply the lacked amount of grease from the ejection outlet.
(8) Wrap seal tapes on socket head plug [Rc-1/4] and attach to the inlet (LUB.PORT).
Wrap seal tapes on socket head plug [Rc-1/4] and attach to the outlet (DRAIN).

[ST133F-01][ST166F-01][ST210F-01]
[ST133TF-01][ST166TF-01][ST210TF-01]

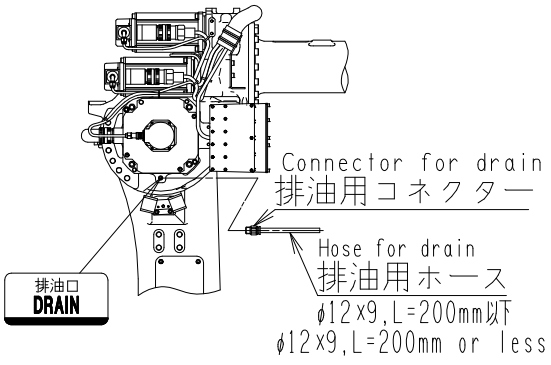


Fig 4.2-10 Connection of drain hose and connector

[ST133F-01][ST166F-01][ST210F-01]
[ST133TF-01][ST166TF-01][ST210TF-01]

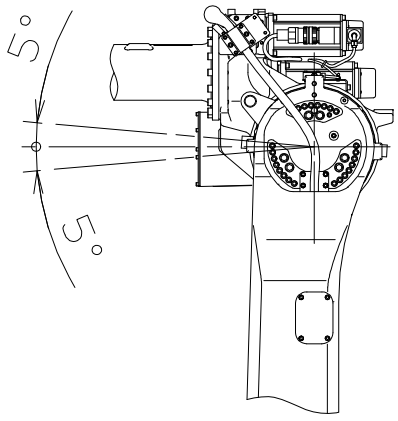


Fig 4.2-11 J3 axis low speed motion range

4.3 Battery replacement

The robot uses lithium batteries for the backup of encoder data. If the battery voltage drops below the given limit, the data will not be kept normal.

CAUTION

Replace the batteries **every 8 years**.
(Under a condition of 8 hours ON and 16 hours OFF every day)

CAUTION

The replacement period varies with use environments (mainly temperatures). Furthermore, if the battery voltage drops below the given limit, an error indicating the voltage drop will be displayed on the controller. In this case, be sure to replace the battery corresponding to the error displayed.

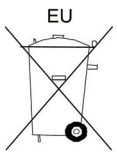
CAUTION

Replace the battery with the primary power supply of the controller turned ON. Replacing the battery with the primary power supply turned OFF can result in the encoder data error, thus requiring the resetting of the encoder.

Do not store the batteries in places with high temperature and high humidity. Store them in well-ventilated places to avoid dew condensation. It is recommended to store the batteries in places with less temperature changes at ambient temperatures (20±15°C) and relative humidity of not more than 70%.

Discarding lithium batteries according to your local trash separation rule

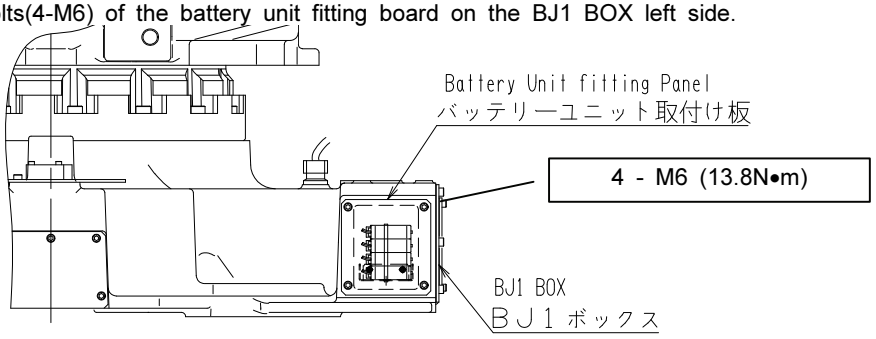
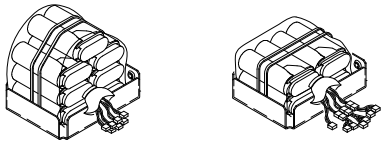
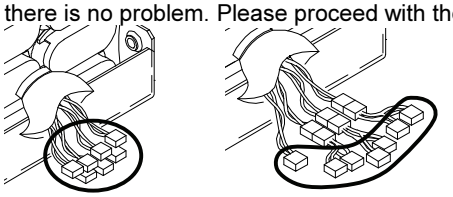
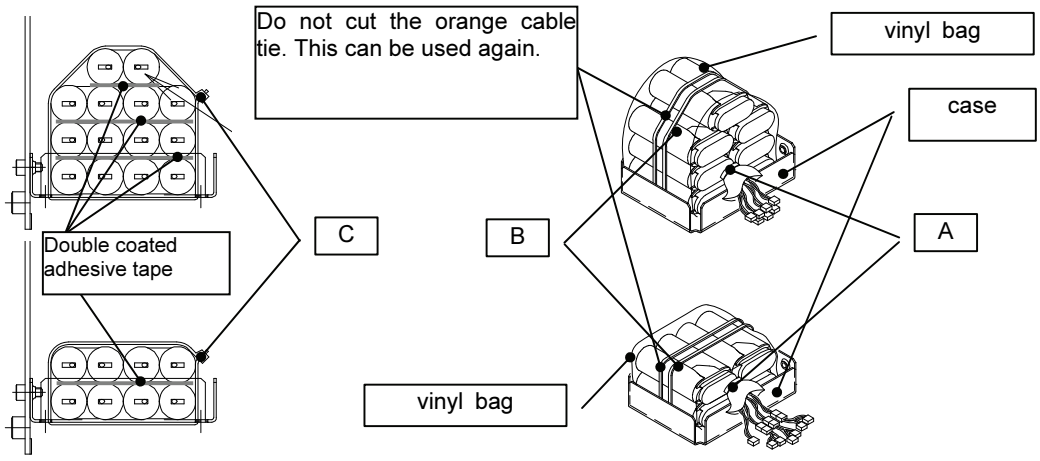
When discarding used lithium batteries, insulate the electrical terminals. And then follow the respective trash separation rules in your local district and discard them separately as ***"Used lithium batteries"***.

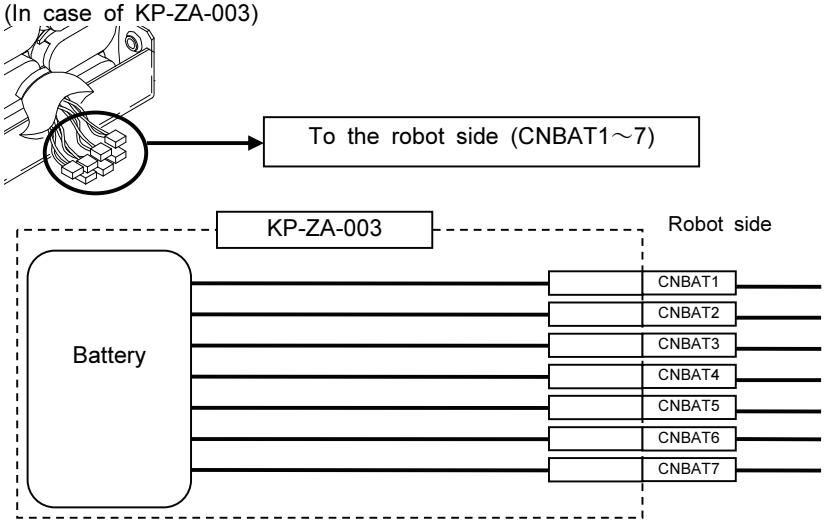
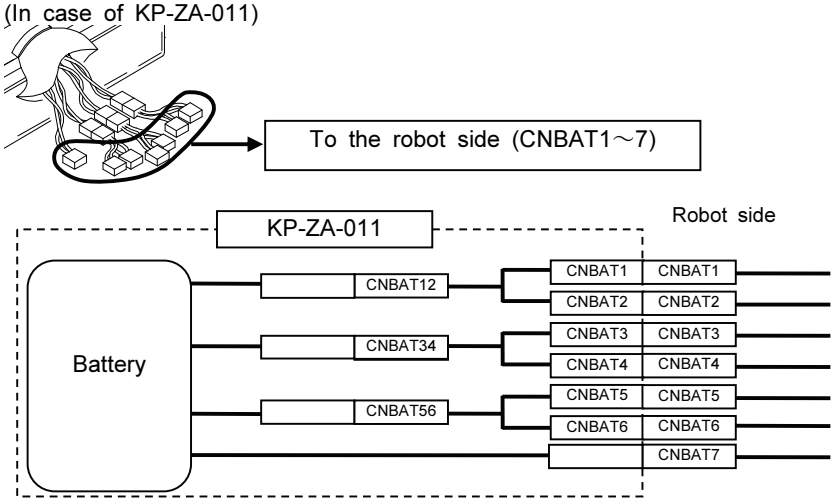


Tools required

- Torque wrench for M4 (Tightening torque : 3.33 Nm)
- Torque wrench for M6 (Tightening torque : 13.38 Nm)
- Double coated adhesive tape
- Nipper, Cable tie

Battery replacement procedure

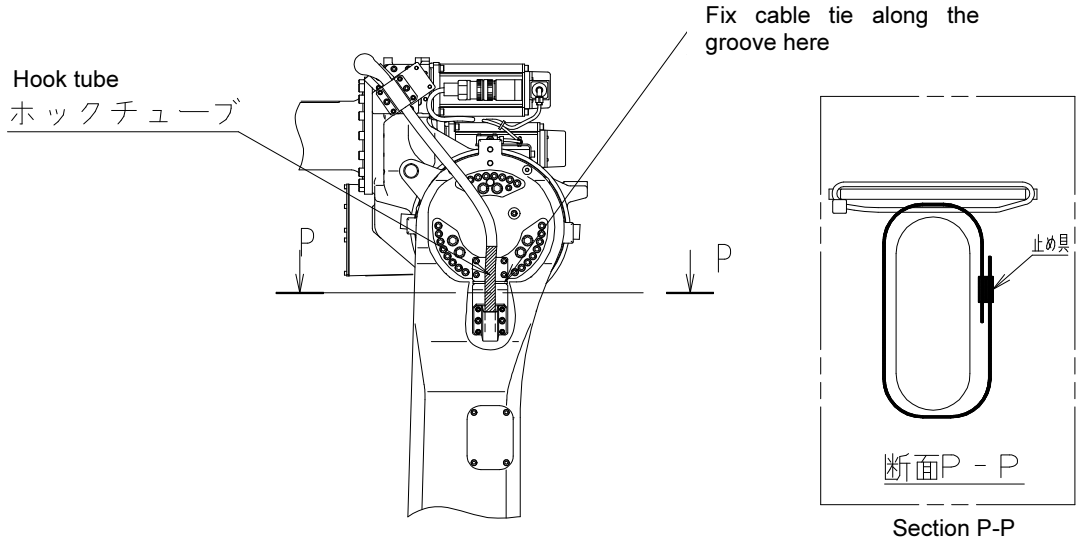
STEP	Work performed
1	Turn ON the primary power of the robot controller.
2	Lock the robot by pressing the emergency stop button.
3	Remove the bolts(4-M6) of the battery unit fitting board on the BJ1 BOX left side. 
4	There exist 2 different battery types.  KP-ZA-003 (7pcs.) KP-ZA-011 (4pcs.)
5	Pull out the battery unit from the BJ1 BOX.
6	Disconnect the connecters. Although a warning message about encoder battery voltage is displayed, there is no problem. Please proceed with the next procedures.  KP-ZA-003 (7pcs.) KP-ZA-011 (4pcs.)
7	Remove the cable tie C to remove the battery unit from the case. 

STEP	Work performed
8	Attach the new battery.
9	To replace the battery unit Connect the 7 connectors like the following figure. Then, fix the unit on the case using the cable tie C. (In case of KP-ZA-003)  (In case of KP-ZA-011)  To replace the respective batteries one by one (1) Replace the concerned battery to a new one. (2) Fix each battery with double coated adhesive tape. (3) Put the battery in the vinyl bag and fasten the cable tie A. (4) Fasten the vinyl bag with the cable tie B. After the connection, install a new battery unit to the case with the cable tie C.
10	Place the battery unit fitting plate to the original position and fix it with the fixing bolts (4-M6).(Tightening torque : 13.8N•m) If the battery unit fitting plate is damaged, please replace it.
11	Press [R/Reset] key 2 times to reset the error.
12	Turn OFF the primary power of the robot controller and turn it ON again.

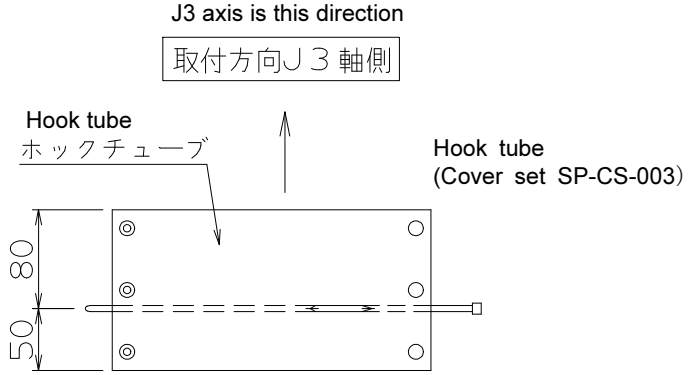
4.4 Wiring cover replacement

The replacement period of the internal wirings of the robot may become shorter than that specified, depending on the use conditions (e.g. continuous operation, operating speed, and environments).
Be sure to perform quarterly periodical inspections (refer to Table 3.1) and check cables and cable covers and hook tube for damage. (If any of manipulator wiring itself is damaged, replace it. But for the replacement, contact our Technical Department.)

There are some inspection locations where the cable covers (silver cover) and the hook tube (gray cover) is used to cover the wires with double covering. Hook tube is maintenance parts used to prevent from rubbing of wires at the moving portion.
If the damaged portion exceeds from 40% to 50%, replace this. Pay attention to the direction of it by referring the figure below, and fix it by using cable tie.



Section P-P



NOTE

Chapter 5 Troubleshooting

5.1 Probing into causes of troubles

Robot failure

Even if any abnormality occurs in the robot, the robot is designed to make an immediate stop as soon as it detects the abnormality. Even though the robot stopped, it is still in a hazardous situation. Under the said condition, NEVER attempt to directly operate the robot.

WARNING

Robot failures are many and varied and include the examples listed below.

1. Abnormalities disabling the robot to operate unless they are rectified once they have occurred.
2. Abnormalities enabling the robot to operate if they are left as-is for a while after they occur.
3. Abnormalities enabling the robot to operate when the power supply is turned OFF once even if they occur.
4. Abnormalities enabling the robot to immediately resume operation even if they occur.
5. Abnormalities causing the robot to malfunction not due to the abnormalities in the robot itself but due to those on the system side.
6. Abnormalities causing the system side to malfunction due to the abnormalities in the robot.

Particularly, in the case of 2, 3, and 4, those abnormalities will surely reoccur. Furthermore, in sophisticated systems, there are numbers of cases where even skilled engineers are unable to easily prove the causes of troubles. If any abnormality occurs in the robot, do not attempt to directly operate the robot. Inform the abnormality to the maintenance personnel who received the given education and training, and then probe the cause of the abnormality to rectify it. Furthermore, incorporate the said course in the Operation Rules and establish a framework to surely implement the Rules. Failure to observe the prescribed rules may result in failures.

When any abnormality occurs in the robot movement or operation, if the controller is in the normal state, the abnormality will result from damage to mechanical parts. To promptly solve troubles, it is necessary to have a good grasp of symptoms and then probe what part is defective to cause the trouble.

Step 1: What axis has caused the abnormality?

Judge what axis has caused the abnormal symptom, first. For abnormalities hard to be judged since they do not appear in the robot movement, check for the following points.

- Any places producing abnormal sounds?
- Any places generating abnormal heat?
- Any places having clearance?

Step 2: What part has damage?

If the axis causing the abnormality is probed, check what part is the cause of the abnormality. A number of parts can be the cause of a single symptom. The following page shows the table of symptoms and causes of troubles.

Step 3: Measures against defective parts

If the defective parts are probed, take measures according to information in Section 5.3. Some measures can be taken by customers. For measures hard to be taken, contact NACHI Service Department.

It is recommended to make use of information in "Troubleshooting" of the T/P Electronic manual for the controller together.

5.2 Symptoms and causes of troubles

As shown below, there are some cases where number of parts causes a single symptom. To judge what parts have damage, refer to information on and after the following page.

Symptoms and causes of troubles

Symptom \ Defective part	Reduction gear	Brake	Motor	Encoder	Balancer bearing	Tool
Overload [Note 1]	○	○	○		○	
Displacement	○		○	○		
Abnormal sound	○	○	○		○	
Shaking while in operation [Note 2]			○		○	
Sway when stopped [Note 3]			○	○	○	○
Irregular twitching [Note 4]			○	○	○	
Abnormal deviation			○	○		
Gravity drop of axis	○	○				
Abnormal heat generation	○	○	○			
Malfunction and runaway			○	○		

[Note 1] A symptom, which will occur when a load exceeding the rated specification conditions of the motor is applied. To be more precise, a thermal relay or a circuit protector will be tripped.

[Note 2] A symptom, which the robot causes vibration while in operation.

[Note 3] A symptom, which the robot will repeat oscillations several times near the stop position when it makes a stop.

[Note 4] A symptom, which the robot twitches at irregular intervals of time in the holding configuration.

5.3 Check and remedy by each part

WARNING

The brake release switch must be operated in order to move the robot without supplying power to its motors (in the Motors OFF status). An axis whose brake has been released is free to move, and since the arm may drop or move either backward/forward or up/down as a result, it must be supported by a crane, chain hoist or other means without fail before the brake release switch is operated.

5.3.1 Balancer bearing

If balancer bearing is damaged, vibration or abnormal sounds will be produced, thus resulting in overload.

[ST133F-01][ST166F-01][ST210F-01]

(1) Checking method

- (Front portion of balancer) Check whether or not the plate shown in Fig.5.3.1-2 is transformed. Furthermore check whether or not (1) bearing attachment portion has some incline (2) grease leaks from seal.
- (Rear left and rear right portion of balancer) At first remove the cover shown in Fig.5.3.1-3 and Fig.5.3.1-4. Next check whether or not (1) grease leaks from the bearing seal (2) seal is transformed such as rolling up of lip portion or rubbing (3) too much rubbing particle is made from the internal shaft (4) bearing and shaft has some incline.
- After checking is completed, remove dust and alien particles and clean before attaching the cover. To attach the rear left cover, fasten the bolt in regulated torque and paint the lock mark.
- Check whether or not the robot hits against the peripheral equipment or else before an abnormality occurs.

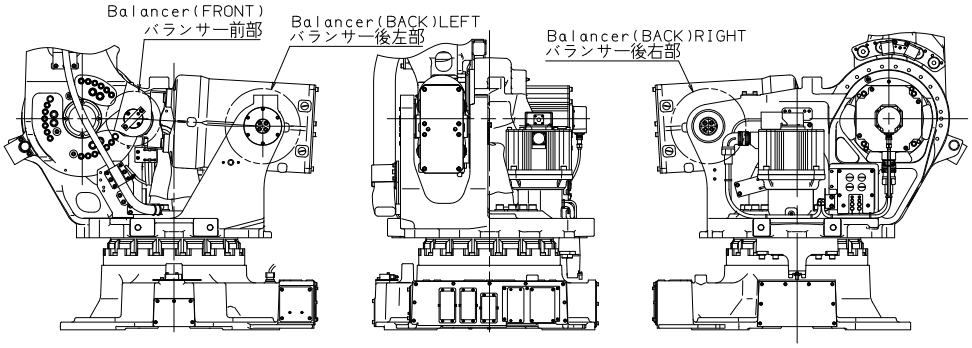


Fig. 5.3.1-1 Checking location

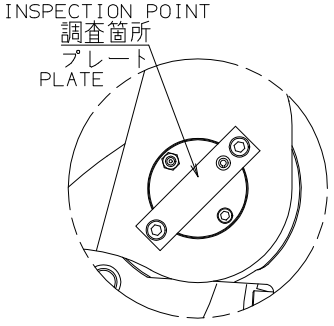


Fig. 5.3.1-2 Checking location
Front portion of balancer

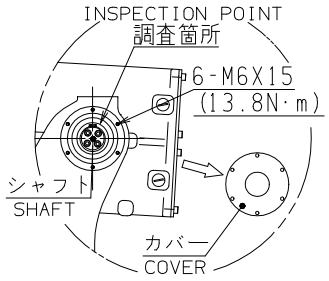


Fig. 5.3.1-3 Checking location
Rear left portion of balancer

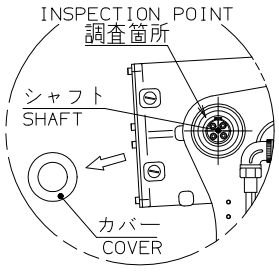


Fig. 5.3.1-4 Checking location
Rear right portion of balancer

[ST133TF-01][ST166TF-01][ST210TF-01]

(1) Checking method

・Check whether or not the plate shown in Fig.5.3.1-6, Fig.5.3.1-7 is transformed. Furthermore, check whether or not (1) bearing attachment portion has some incline (2) grease leaks from seal.

・Check whether or not the robot hits against the peripheral equipment or else before an abnormality occurs.

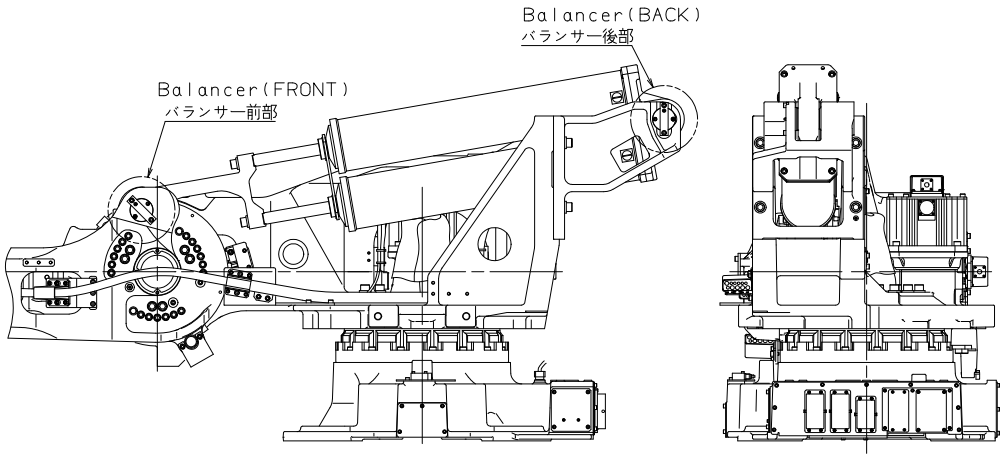


Fig.5.3.1-5 Checking location

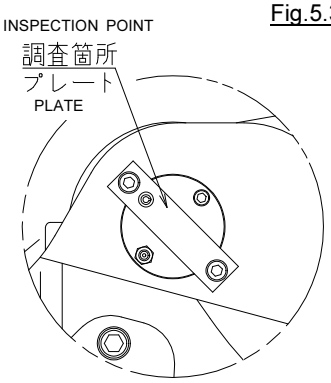


Fig.5.3.1-6 Checking location
Balancer (FRONT)

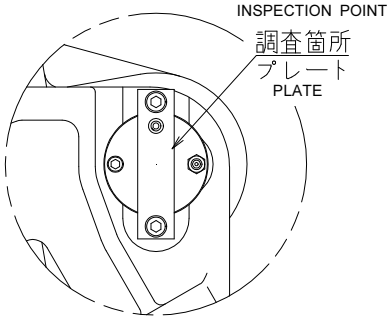


Fig.5.3.1-7 Checking location
Balancer (BACK)

(2) Remedy

• Replace the bearing. For this purpose, in order to lift the robot arm, equipment such as a chain block should be provided. If it is hard to replace the bearing, contact our Technical Department.

5.3.2 Reduction gear

If a reduction gear is damaged, vibration or abnormal sounds will be produced. In this case, normal operation will be impaired to cause overload or abnormal deviation, thus resulting in abnormal heat generation. Furthermore, the robot will completely stop or cause displacement.

J1, J2, and J3 axes

(1) Checking method

- While in operation, check for any vibration or abnormal sounds, or abnormal heat generation from the reduction gear part.
- Check the reduction gear for backlash/play or scratch, and whether or not any abnormality is felt by hand through holding the forearm to swivel the robot with the brake release switch (option) of the J1 axis set to “ON”. To check J2 and J3 axis, upper arm must be held using crane or chain block before releasing. Move the arm by operating crane or chain block and check whether or not any abnormality is felt by hand.

WARNING

Never forget that upper arm must be held using crane or chain block before releasing.
Especially as for J2 axis, upper arm may fall down or may jump up due to the payload and robot posture. After supporting upper arm, release brake by inching operation to see the moving direction of upper arm and to secure that supporting method is adequate.

- Check whether or not the robot hits against the peripheral equipment or else before an abnormality occurs.
  (The reduction gear may be damaged by shocks given when the robot hits against it.)

(2) Remedy

- Replace the reduction gear. For this purpose, in order to lift the robot arm, equipment such as a chain block should be provided. If it is hard to replace the bearing, contact our Technical Department.

J4, J5, and J6 axes

(1) Checking method

- While in operation, check for any vibration or abnormal sounds, or abnormal heat generation from the reduction gear part.
- Check the reduction gear for backlash/play through applying loads to the end effector (e.g. a spot gun or hand unit).
- Turn OFF the motors, and then check whether or not the axis moves by hand with the brake release switch (option) set to “ON”. If the axis does not move, the reduction gear has an abnormality.

WARNING

Before operating the brake release switch, be sure to hold the wrist unit, and the end effecter using crane or chain block etc. in advance.

- Check whether or not the robot hits against the peripheral equipment or else before an abnormality occurs.
  (The reduction gear may be damaged by shocks given when the robot hits against it.)

(2) Remedy

- If J4 axis reduction is abnormal. just replace J4 axis reduction gear.
- If J5 or J6 axis reduction gear is abnormal, please replace the whole wrist part.
  (The replacement of the reduction gear needs time and equipment is needed to do it. Replacing the whole wrist part enables prompt and reliable remedy.)

enables prompt and reliable remedy.)

5.3.3 Brakes

If any brake causes an abnormality, an axis may drop with the motors “OFF”. Furthermore, with the motors “ON”, the brake may remain applied, thus resulting in overload or noises.

(1) Checking method

- With the Motors OFF state, check whether or not the brake produces operating sounds through setting the brake release switch to “ON” and “OFF”. If the brake produces no operating sounds, it is assumed that the brake has a broken wiring.
  (In order to set the brake release switch to “ON” or “OFF”, pay utmost care for the drop of the robot arm. The brake release switch is option. Mount the brake release switch prior to the investigation.)

WARNING

Before operating the brake release switch, be sure to hold the arm, the wrist unit, and the end effecter using crane or chain block etc. in advance.
Especially as for J2 axis, upper arm may fall down or may jump up due to the payload and robot posture. After supporting upper arm, release brake by inching operation to see the moving direction of upper arm and to secure that supporting method is adequate.

(2) Remedy

- Check for brake wirings. Since the motor with an integrated brake for all axes is used, if no wirings are broken, replace the motor referring to information in “5.4 Motor Replacement”.

5.3.4 Motor

If the motor causes an abnormality, malfunctions (e.g. shaking while in operation, sway when stopped, or irregular twitching) will result. Furthermore, abnormal heat generation or abnormal sounds may result. Since the same symptoms as those caused when the reduction gear is damaged appear, it is hard to judge whether the abnormality results from the motor or the reduction gear. In this connection, investigate the reduction gear and the bearing at the same time.

(1) Checking method

- Check for any abnormal sounds or abnormal heat generation.

(2) Remedy

- Replace the motor referring to information in “5.4 Motor Replacement”.

5.3.5 Encoder

If the encoder causes an abnormality, the robot will cause displacement, malfunction, or runaway, thus leading to sway when stopped or irregular twitching. Furthermore, this abnormality will almost never result in symptoms such as mechanical noises, heat generation, or vibration.

(1) Checking method
- Check the encoder data for any errors.
- Align the zeroing pin with the reference position, and then check the position data for any errors.
- Move each axis of the robot to check whether or not there are any points in which data (bits) show irregular changes.
- Check the controller for the model of drive unit. (The model of the drive unit varies with the number of robot axes in use and the motor capacity of followed axis.)
- If any drive unit of the corresponding model for the same model of controller is available, replace the drive unit to check whether or not the symptom is transferred to this drive unit, referring to Maintenance Manual of Controller.

(2) Remedy
- Check for brake wirings. If no wirings are broken, replace the encoder.
- When the drive unit is replaced, if the symptom is transferred to this drive unit, replace this drive unit.

CAUTION

Caution on the encoders

If the battery has discharged completely or if the battery is not connected properly so that the encoder has been left standing without any power supplied to it from the controller, the data stored inside the encoder may be lost and the encoder itself may not operate properly. This state is detected as an abnormality in the encoder system when the encoder operation is checked at power-on. When abnormal encoder circuit condition has been detected, encoders must be reset.

5.3.6 Tool

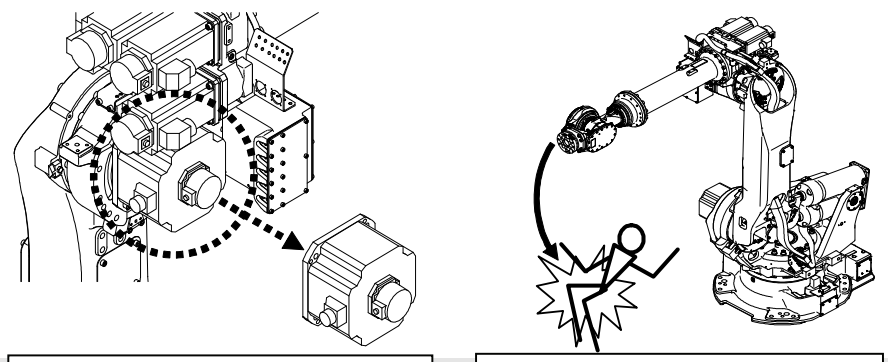
If the tool which is not so rigid has been mounted on the robot, the tool itself may repeat oscillations several times near the stop position.

In this case, robot teaching program is needed to be modified. For example, reducing the step speed or recording “smooth” parameter. (☞ “Basic Operations manual” ”Chapter 4 Teaching”)

5.4 Motor replacement

Dismounting the motor from the robot without properly supporting the arm can cause the arm to drop or move forward or backward. Be sure to properly support the arm before dismounting the motor.

WARNING



Dismounting the motor from the robot without properly supporting the arm...

The arm can drop from the robot or move forward or backward.

After inserting a zeroing pin, to prevent the arm from dropping, support the arm using wooden blocks or a crane, and then dismount the motor from the robot. (Note that the zeroing pin and block are used for the reference position adjustment, not for supporting the arm.)
Furthermore, NEVER attempt to hold the robot arm with hands.

CAUTION

To touch the motor immediately after it stops, check to be sure that the motor is not hot, and then touch it with care. The motor mass is listed in the table below. Consequently, handle the motor with care.

Robot type	Motor mass		
	J1,J3	J2	J4,J5,J6
ST133F-01, ST166F-01	24.3 kg	24.3 kg	11.0 kg
ST210F-01 ST133TF-01,ST166TF-01,ST210TF-01	24.3 kg	27.0 kg	11.0 kg

CAUTION

This work includes some jobs that should be conducted with the motors ON. Consequently, be sure to conduct the work at least by a pair of two persons. One person must stay on guard to press an Emergency Stop button at any time, while the other person must promptly finish the work with thorough attention paid to the robot operating area. Furthermore, prior to starting the work, check for safe corridors.

After the completion of motor replacement, check to be sure that the zeroing pin has been removed, and then operate the robot. Note that operating the robot with the zeroing pin inserted may bend the pin or deform the hole for this pin, thus disabling proper positioning of the zeroing pin.

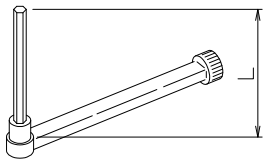
CAUTION

Do not add large pressure onto the encoder connector of the motor. If large pressure is added, the connector may be broken.

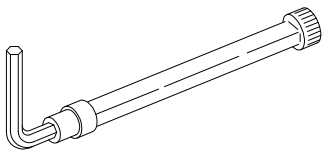
Tools required

Part name	Axis name	Part No. (Model)	Remark
Torque wrench (prepared by customer)	J1	M3 torque wrench	
	J1, J2, and J3	M5 torque wrench (Long type: Not less than 200 mm in length) Or M5 L type torque wrench	*4
	J4, J5, and J6	M5 torque wrench	
	J1, J2, and J3	M12 torque wrench (Long type: Not less than 280 mm in length)	*1, *2
	J4, J5, and J6	M8 torque wrench (Long type: Not less than 280 mm in length)	*1, *3
Locking agent	J4, J5, and J6	ThreeBond 1374	
Grease	J4, J5, and J6	LONGTIME PD2	Compatible grease; ALVANIA RA
	J1, J2, and J3	MOLYWHITE RE No.00	
Lubrication	J1, J2, and J3	ThreeBond 1801B	

*1 Use a commercially-available long wrench or extension wrench.
*2 Used for spindle motor replacement
*3 Used for wrist axis motor replacement and for mounting of zeroing block
*4 Use the long wrench or L type tor que wrench on the market.



Torque wrench



L type Torque wrench

CAUTION

About “coupling gear set”

The “coupling gear set” described in the chapter 6 includes motor fixing bolts, O-rings , sheet packing also. When replacing a motor unit, it is recommended to replace the old bolts, O-rings and sheet packings to the new ones that are included in the set in spite of their damage level.

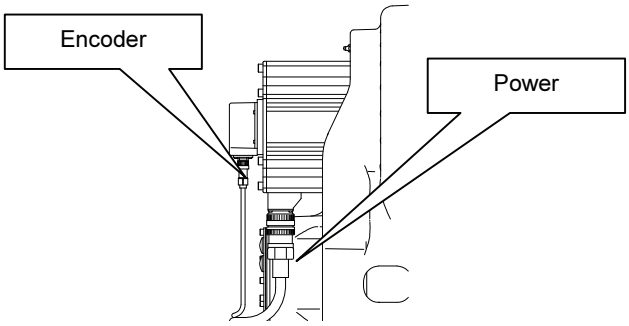
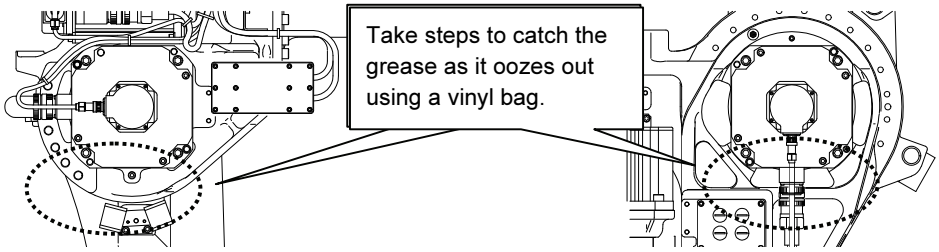
5.4.1 Motor replacement (J1, J2 and J3)

Procedure of replacing J1, J2 and J3-axis motors

STEP	Work performed	Checkpoints
1	Turn on the primary power of the controller, select the TEACH mode, and select Motors ON.	If Motors ON cannot be selected due to an abnormality or axis operations cannot be performed, start from step 3.
2	Refer to “5.4.4 Encoder correction” to proceed with the axis operation to the position where the zeroing pin can be inserted and to insert the zeroing pin.	
3	Secure the arm using a crane, chain block or other means.	As for J2 and J3 axis, if Motors ON cannot be selected due to an abnormality or axis operations cannot be performed, it is possible to secure the arm using the arm securing fixture (option).

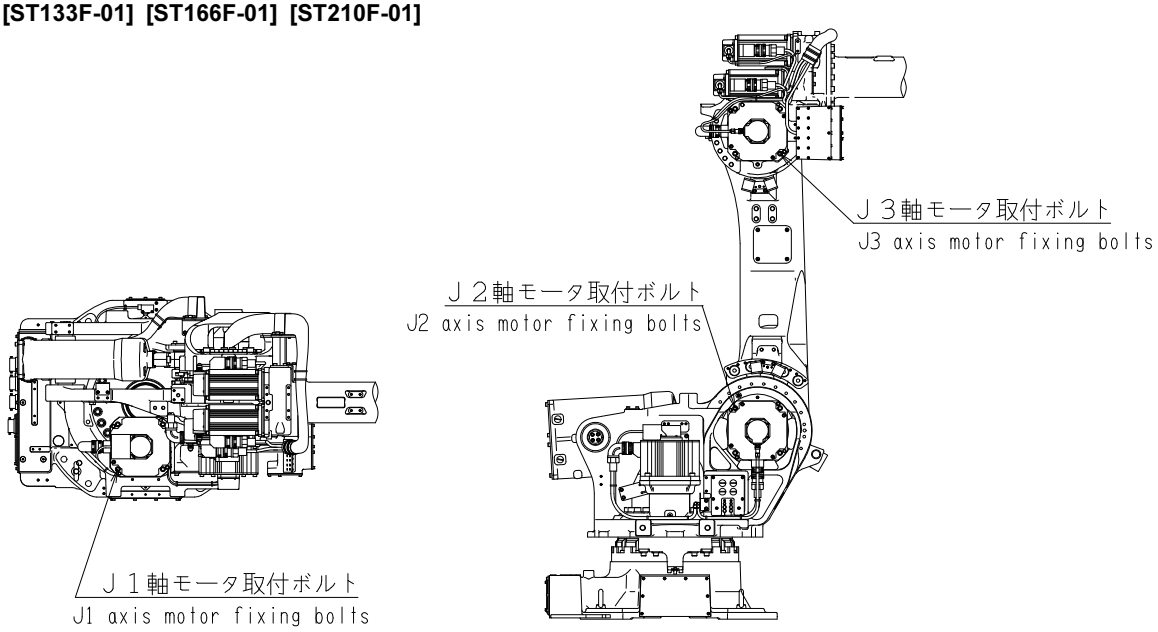
WARNING

Be absolutely sure to follow the above instructions to secure the arm ahead of time. Removing the motor without first securing the arm may cause the arm to move forward or backward or drop, resulting in a serious accident.

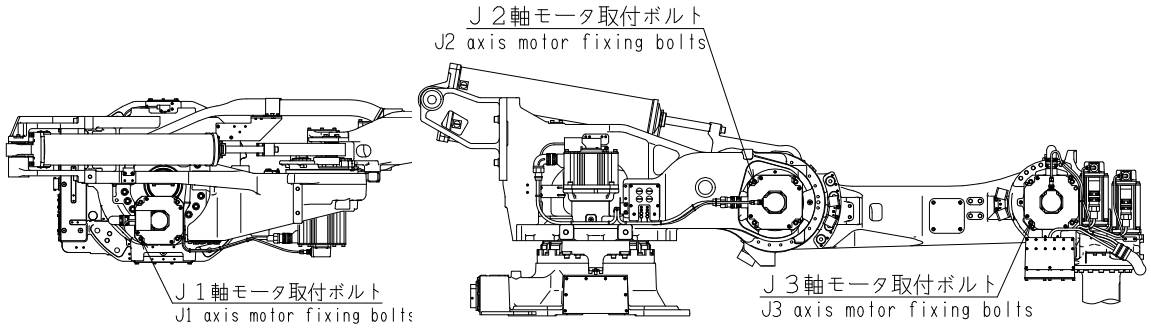
4	Set to Motors OFF first, and then turn off the primary power of the controller.	
5	Disconnect the connectors (encoder and power) from the motor.	Bear in mind that the encoder data will be lost when the encoder connector is disconnected.
		
6	Place a vinyl bag for catching the grease under the motor. (In the case of J1 axis, it is not necessary to attach the vinyl bag.)	• In the case of the J2 or J3 axis, grease will ooze out when the motor is removed. • Fix the vinyl bag securely in place using adhesive tape or some other means.
		

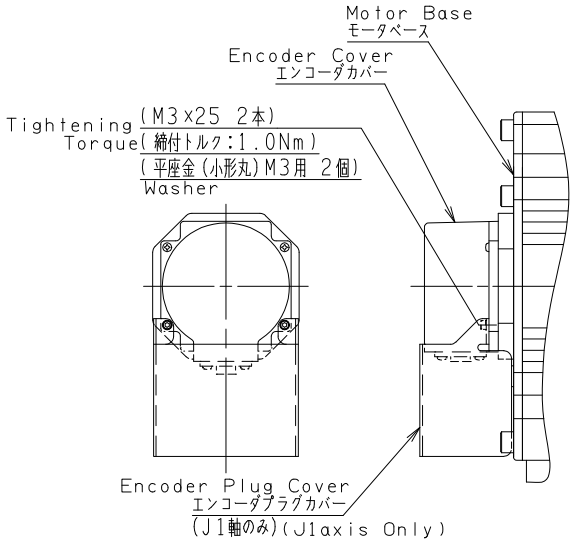
STEP	Work performed	Checkpoints
7	Remove the motor attachment bolt shown below, and remove the motor from the robot. For the position of the bolt, refer to Fig. 5.4.1-3. J1,J2,J3 **4-M12 X 30**	• Exercise caution since the J1, J2 and J3 axis motors are heavy. • Do not to apply excessive impact to the motor shaft. • Take care not to damage the oil seal lip by the gear attached to the motor shaft. • Bear in mind that when the J2 axis motor is removed, the J2 axis may move forward or backward depending on the state of the frame balancer.

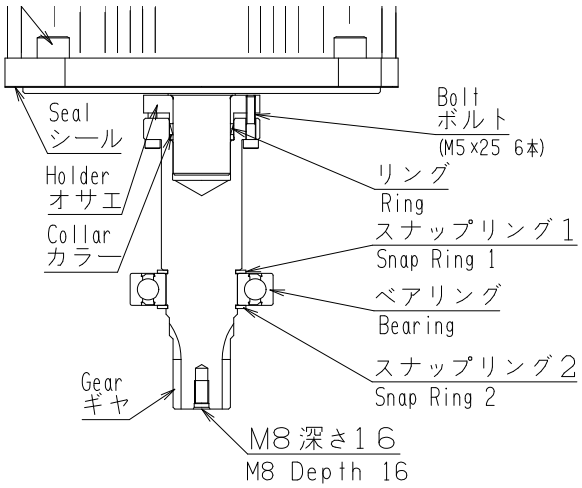
[ST133F-01] [ST166F-01] [ST210F-01]



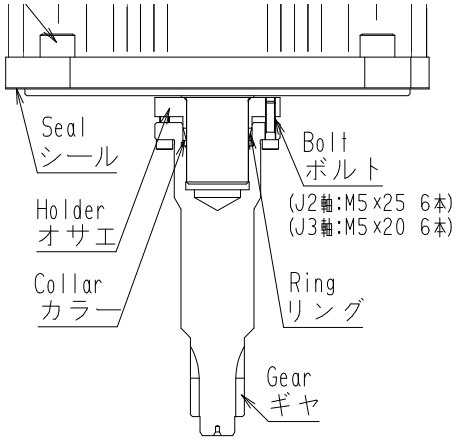
[ST133TF-01][ST166TF-01][ST210TF-01]



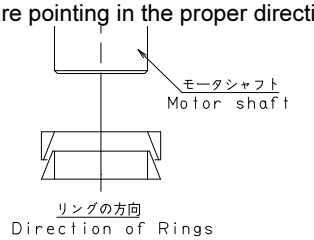
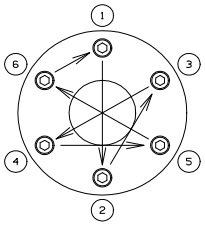
STEP	Work performed	Checkpoints
8	Remove the encoder plug cover (only J1 axis) (J2 and J3 axis are option). Refer the following drawing. J1 **2-M3 X 25**  	
9	Remove the gear-assy from the motor. J1 When using M5 long type torque wrench (a) Remove the bearing. (b) Remove the following bolts, and remove the gear. **6-M5 X 25** (c) Attach the collar, ring X2 and holding plate. When using M5 L type torque wrench (a) Remove the following bolts, and remove the gear. **6-M5 X 25** (b) Attach the collar, ring X2 and holding plate. J2, J3 (a) Remove the following bolts, and remove the gear. **J2 axis : 6-M5 X 25** **J3 axis : 6-M5 X 20** (b) Attach the collar, ring X2 and holding plate.	• Do not apply excessive impact to the motor shaft. • To remove bearings, remove snap ring using pulley remover on the market and put the hook on the internal bearing. (Do not put the hook on the external bearing to avoid any damages on it)

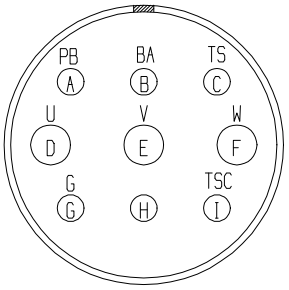
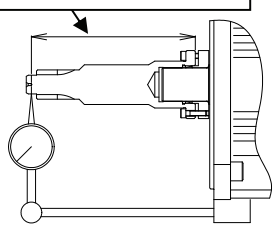
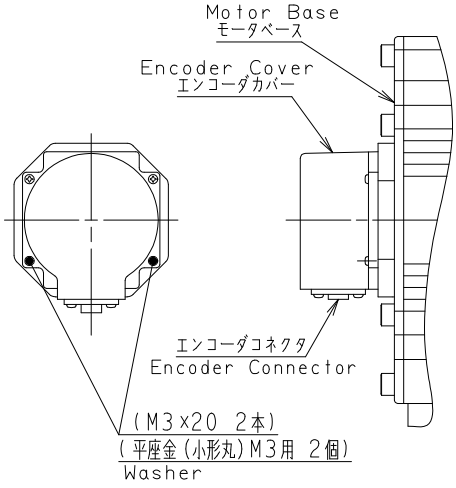


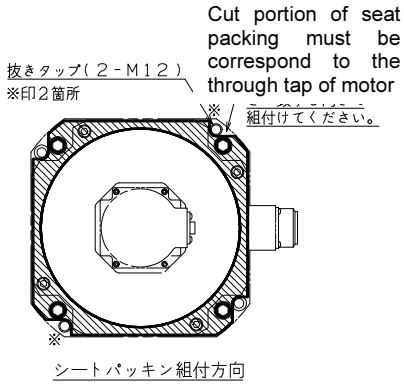
J1 axis Cross-sectional view of gear-ASSY



J2 and J3 axis Cross-sectional view of gear-ASSY

STEP	Work performed	Checkpoints
10	Attach the gear-assy, which was removed, to the new motor. Refer to the figures shown as above.. J1 When using M5 long type torque wrench (a) Attach the holding plate, ring X2 and collar. (b) Using the following bolts, attach the shaft-assy. **6-M5 X 25 (tightening torque: 9.8 N·m)** (c) Attach bearing . When using M5 L type torque wrench (a) Attach the holding plate, ring X2 and collar. (b) Using the following bolts, attach the shaft-assy. **6-M5 X 25 (tightening torque: 9.8 N·m)** J2, J3 (a) Attach the holding plate, ring X2 and collar. (b) Using the following bolts, attach the shaft-assy. **J2 ; 6-M5 X 25 (tightening torque: 9.8 N·m)** **J3 ; 6-M5 X 20 (tightening torque: 9.8 N·m)** (c) Check the *run-out tolerance* of the gear. (The run-out tolerance should be under 0.1mm) If the run-out tolerance exceeds 0.1 mm, loosen the gear fixing bolts and repeat the steps from (b)	• Apply a thin coating of ThreeBond 1801B to the shaft of the new motor and two rings before attaching the gear-assy to the new motor. • When attaching the rings, make sure they are pointing in the proper direction.  • Do not to apply excessive impact to the motor shaft. • The bearing should be installed by pushing the inner side ring. If the outer ring is pushed, the bearing may be broken. • Be absolutely sure to use the torque wrench to attach the bolts. Then tighten bolts gradually & uniformly using a torque wrench. 

STEP	Work performed	Checkpoints
(10)	(Supplement) To check the run-out tolerance, it is necessary to release the brake inside the motor and rotate the gear by hand. To release the brake, add DC24V voltage between pin A and pin B in the CNMB* connector. (A:+24V, B:0V)  	•The run-out tolerance should be measured on the oil-seal touching surface using a dial gauge like shown as below. J2 axis : RV-450E-*(with stamp) 173mm RV-450E-*(without stamp) 180mm J3 axis :158mm  • To identify the gear type, refer to the section of "6.1 Recommended spare parts".
11	Remove two encoder cover fixing bolts at the encoder connector side (only J1 axis).Refer the following drawing.  Attach the removed encoder plug cover (only J1 axis) (J2 and J3 axis are option) to the new motor, refer to the STEP8. J1 Attach encoder plug cover with following bolts. **2-M3 X 25 (tightening torque: 1.0 N·m)** **2-flat washers (small/round) for M3 (used from the beginning)**	

STEP	Work performed	Checkpoints
12	Attach motor with following bolts. J1,J2, J3 **4-M12 X 30 (tightening torque: 116 N·m)**	• Bear in mind to use torque wrench to fasten the bolts. Fastening should be done equally and gradually. • Bear in mind not to damage the gear surface when attaching the motor. • If sheet packing of motor is damaged, please replace it to the new one. Its direction is as followed.  Sheet packing attaching direction
13	Connect the connectors (encoder and power) to the motor.	
14	During the replacement of J2 and J3-axis motors grease can be lost. Estimate amount of grease lost during replacement procedure and replenishment. (grease : MOLYWHITE RE No.00)	
15	Refer to “5.4.3 Encoder reset” to reset the encoder of the axis whose motor has been replaced.	
16	Refer to “5.4.4 Encoder correction” to proceed with the encoder correction for the axis whose motor has been replaced.	• If a motor has been replaced in a posture that prevents the zeroing pin from being inserted, proceed with encoder reset and encoder correction to enable axis operation, and then once more move the axis to the position where the zeroing pin can be inserted, and proceed with encoder reset and encoder correction again.
17	Remove the zeroing pin.	• Bear in mind that performing an axis operation by mistake without first having removed the zeroing pin may deform the pin and/or pin hole and make it impossible to remove the pin and implement encoder correction properly in the future. • If the zeroing pin cannot be removed, move the axis a little at a time at manual speed 2, and then remove the pin.
18	Ensure that the robot operation presents no problem.	

This now completes the J1, J2 or J3 axis motor replacement.

5.4.2 Motor replacement (J4, J5 and J6)

CAUTION

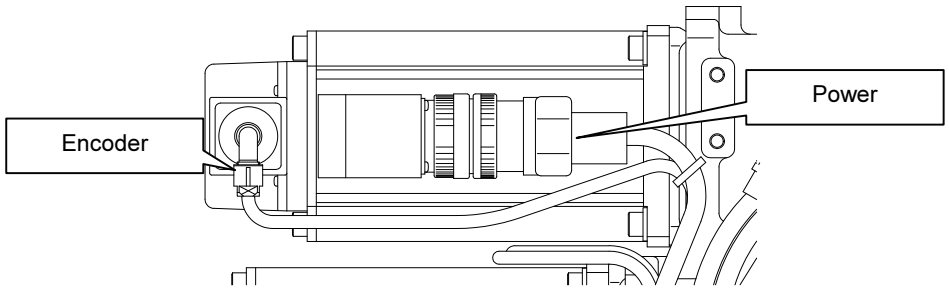
Axis interference of wrist axis (J4,J5 and J6 axis)
"Axis interference" exists due to the structure of the wrist on this robot.
For this reason, when performing encoder correction of J5 axis, J4 axis must be in reference position (zeroing pin position). Similarly, when performing encoder correction of J6 axis, J4 and J5 axis must be in reference position (zeroing pin position).
This means that encoder correction must be performed in the sequence of the 4, 5 and 6 axes without fail. If encoder correction has not been performed in this sequence, the zero points of the wrist axes will not be set correctly and the robot will not move properly.

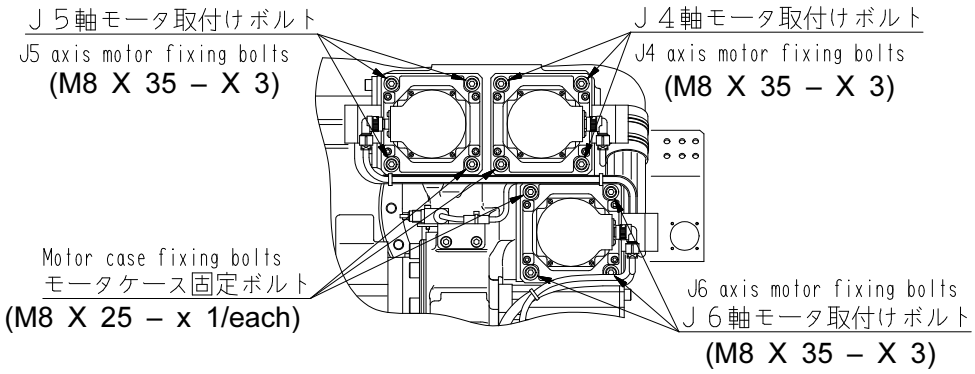
Procedure of replacing J4, J5 and J6-axis motors

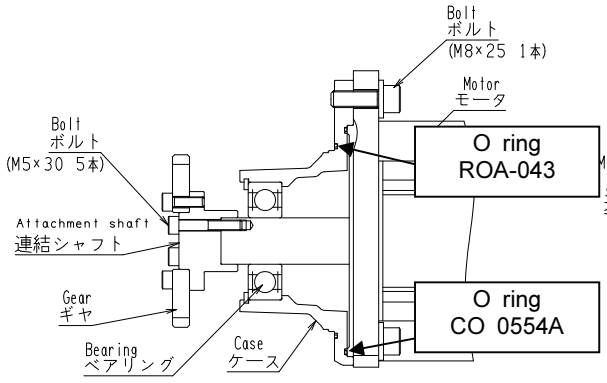
STEP	Work performed	Checkpoints
1	Turn on the primary power of the controller, select the TEACH mode, and select Motors ON.	If Motors ON cannot be selected due to an abnormality or axis operations cannot be performed, start from step 3.
2	Refer to "5.4.4 Encoder correction" to proceed with the axis operation to the position where the zeroing pin can be inserted and to insert the zeroing pin.	The work to be performed after motor replacement is made easier if the zeroing pins are left inserted ahead of time.
3	Secure the wrist and tool using a crane, chain block or other similar means.	

WARNING

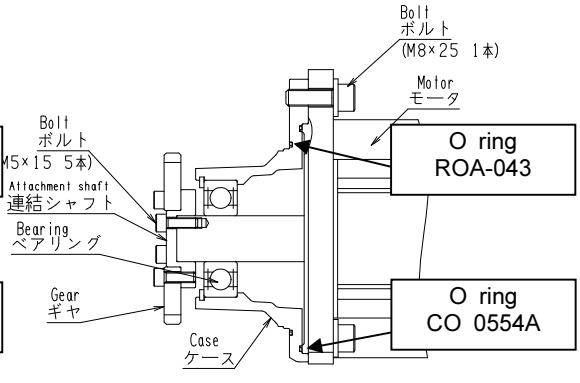
Be absolutely sure to follow the above instructions to secure the wrist and tool ahead of time. Removing the motor without first securing the wrist and tool may cause the wrist to rotate suddenly or drop, resulting in a serious accident.

4	After making Motors OFF status, turn OFF the primary power of the controller.	
5	Disconnect the connectors (encoder and power) from the motor.	Bear in mind that the encoder data will be lost when the encoder connector is disconnected.
		

STEP	Work performed	Checkpoints
6	Remove the following motor attachment bolts, and remove the motors from the robot. **3-M8 X 35**	• Do not to apply excessive impact to the motor shaft. • At this point, the motor case fixing bolts need not be removed.
		
7	Follow the steps below to remove the gear-assy attached to the motor shaft. (Refer to the following figures.) (a) Remove the following bolts (inner side), and remove the gear. **J4 axis : 5-M5 X 30** **J5 and J6 axis : 5-M5 X 15** (b) Remove the following bolts, and remove the motor case. **1-M8 X 25 (motor case fixing bolts)**	• Do not to apply excessive impact to the motor shaft. • The outer side bolts are not needed to be removed.



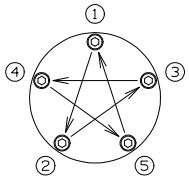
Cross-sectional view of J4 axis motor gear-assy



Cross-sectional view of J5 and J6 axis motor gear-assy

WARNING

Connecting shaft of J4 axis gear and motor is different from that of J5 and J6 axis. Pay much attention when attaching those. (refer to STEP6 to see the motor location)

STEP	Work performed	Checkpoints
8	Attach the gear-assy, which was removed, to the new motor. (Refer to STEP7) (a) Attach the motor case to the motor using the foll owing bolts. **1-M8 X 25 (tightening torque: 33.3 N·m)** (b) Attach the gear to the motor shaft using the follo wing bolts. At this point, apply one or two drops of locking agent (ThreeBond 1374) to the threads at the ends of the bolts, and then tighten the bo lts. **J4 axis : 5-M5 X 30 (tightening torque: 8.1 N·m)** **J5 and J6 axis : 5-M5 X 15 (tightening torque: 8.1 N·m)**	• Clean the shaft of the new motor. (Remove dusts, redundant oil, etc.) • If the O-ring is damaged, please replace it. • Take care not to damage the O-ring when attaching the motor case. • Be absolutely sure to use the torque wrench to attach the bolts. Then tighten bolts gradually & uniformly using a torque wrench. 
9	Apply the appropriate amount of grease (LONGTIME PD2) to the gear teeth (enough to cover the teeth), and attach the motor to the robot using the following bolts. **3-M8 X 35 (tightening torque: 33.3 N·m)**	• Be absolutely sure to use the torque wrench to attach the bolts. Then tighten bolts gradually & uniformly using a torque wrench. • Take care not to damage the gear teeth. • If the O-ring is damaged, please replace it. • Although ALVANIA RA grease is filled in the gear box, LONGTIME PD2 can be lubricated there (if the amount is small) because it has the same lithium soap base and the same consistency with ALVANIA RA.
10	Connect the connectors (encoder and power) to the motor.	
11	Refer to “5.4.3 Encoder reset” to proceed with encoder reset.	
12	Refer to “5.4.4 Encoder correction” to proceed with encoder correction.	• If a motor has been replaced in a posture that prevents the zeroing pin from being inserted, proceed with encoder reset and encoder correction to enable axis operation, and then once more move the axis to the position where the zeroing pin can be inserted, and proceed with encoder reset and encoder correction again.
13	Remove the zeroing pin. Remove the zeroing block, and attach the cover using the bolts (2-M8).	• Bear in mind that performing an axis operation by mistake without first having removed the zeroing pin may deform the pin and/or pin hole and make it impossible to remove the pin and implement encoder correction properly in the future. • If the zeroing pin cannot be removed, move the axis a little at a time at manual speed 2, and then remove the pin.
14	Ensure that the robot operation presents no problem.	

This now completes the J4, J5, or J6 axis motor replacement.

5.4.3 Encoder reset

When encoder data has been corrupted due to some problem or motor replacement it is necessary to reset an encoder and compensate for any offset between actual encoder position and pin (reference) position. In cases like this, encoder reset must be performed first so follow the steps below to initiate encoder reset.

WARNING

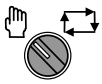
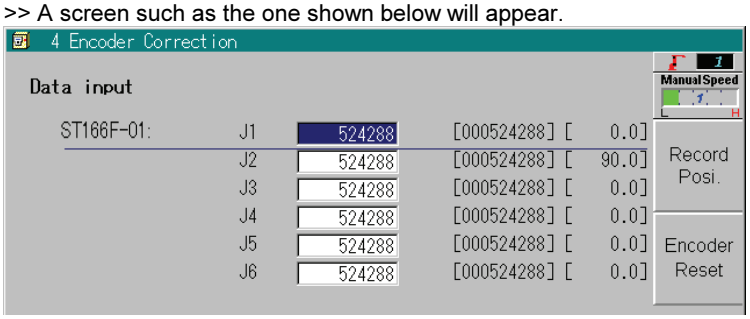
The encoder data will be initialized when encoder reset is performed so the robot will no longer move properly. Upon completion of encoder reset, therefore, be absolutely sure to use the zeroing pin to perform encoder correction. If the work program is played back without encoder correction having been performed correctly, the robot may act incorrectly so that the operator may be caught or sandwiched by the robot parts, possibly resulting in death or serious injury.

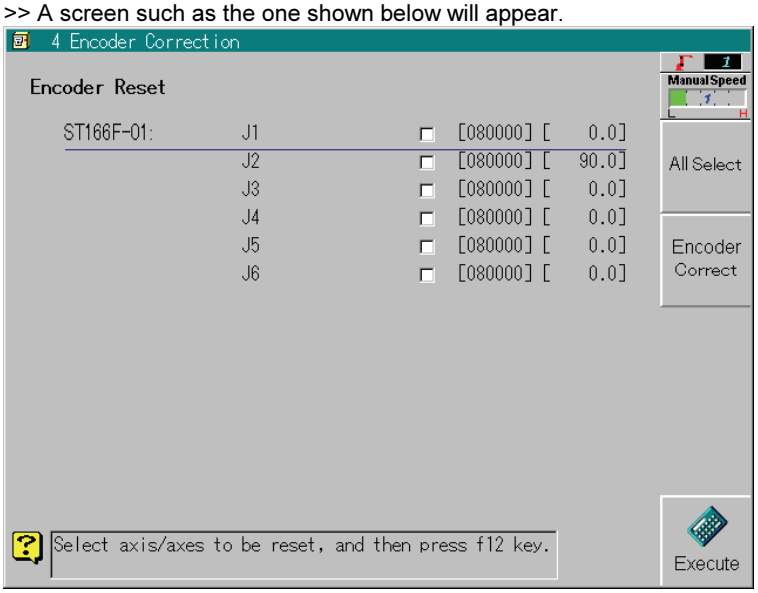
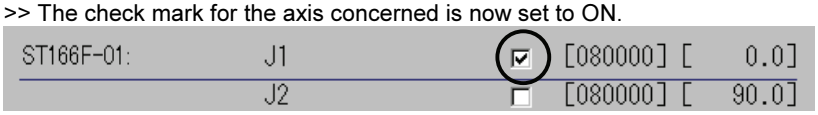
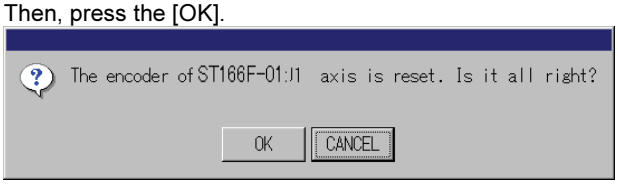
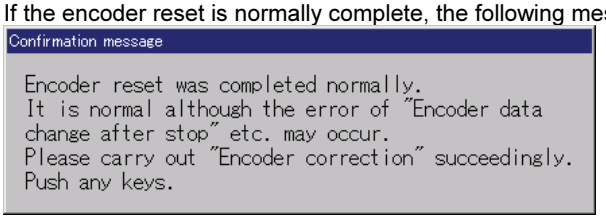
CAUTION

After performing the motor connections, the following errors may arise due to the discharge of the super capacitor inside the encoder. (Example: In cases where, for instance, a new motor whose super capacitor is charged has been connected)
E0050: Encoder counter overflow/underflow
E0052: Encoder battery charge low
In a case like this, supply power to the controller for at least 10 minutes, and then reset the encoder. After this, turn the controller power off and then back on to restore the normal state.

No special tools are necessary for encoder reset procedure.

Encoder reset procedure

	1	Supply the primary power to the controller for at least 10 minutes. Then set to the Motors OFF state.
	2	Select the [TEACH] mode.
	3	Before proceeding, switch the operator qualification to ***Expert.***
	4	Select [Constant Setting] [3 Machine Constants] [4 Encoder Correction]. >> A screen such as the one shown below will appear. 

Encoder Reset	5	Press f9 [Encoder Reset]. >> A screen such as the one shown below will appear. 
ENABLE + ON / 1	6	Align the cursor with the axis for which encoder reset is to be performed, and press [ENABLE] + [ON/1]. >> The check mark for the axis concerned is now set to ON.  Point • To clear the check mark, press [ENABLE] + [OFF]. • To set the check mark for all the axes at the same time, press f8 [All Select].
Execute	7	After the axes have been selected, press f12 [Execute]. >>The following message will be displayed by axis for which the checkmark is placed. Then, press the [OK].  Encoder resetting will be executed.
	8	If the encoder reset is normally complete, the following message will be displayed. 

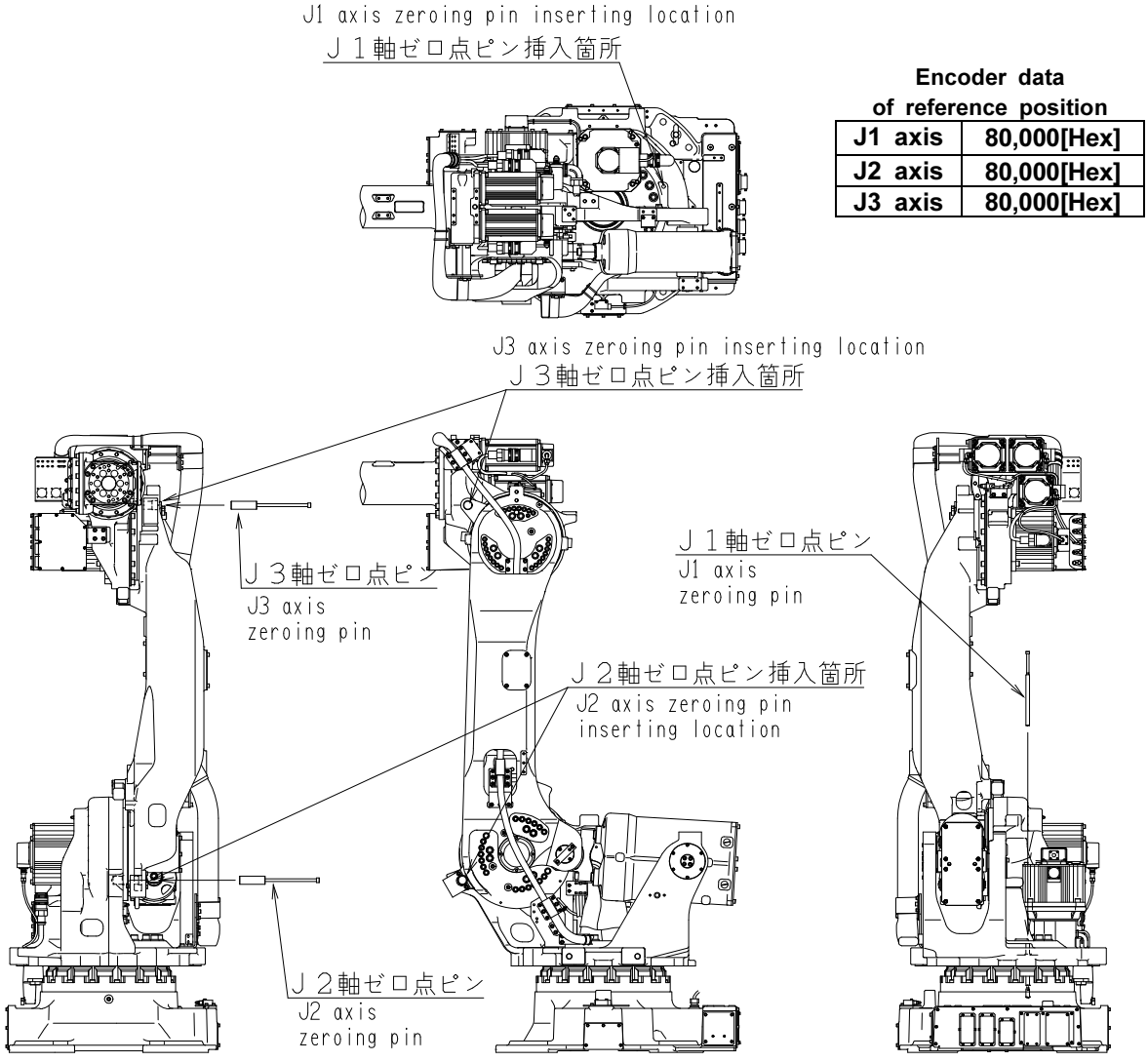
This now completes the encoder reset procedure. Refer to the next section, and proceed with encoder correction.

5.4.4 Encoder correction

After performing encoder reset procedure, encoder correction must be implemented. This is to registering the “encoder correction value” so that encoder data becomes the pre-determined value at the pre-determined position (this is called **reference position**, zeroing pin can be inserted here).

Reference position (zeroing pin position) and its encoder data are explained in following pictures. These encoder data are very important to check the successful procedure of encoder correction.

[ST133F-01] [ST166F-01] [ST210F-01]
Reference position (Zeroing pin insertion portions) of J1,J2 and J3 axis

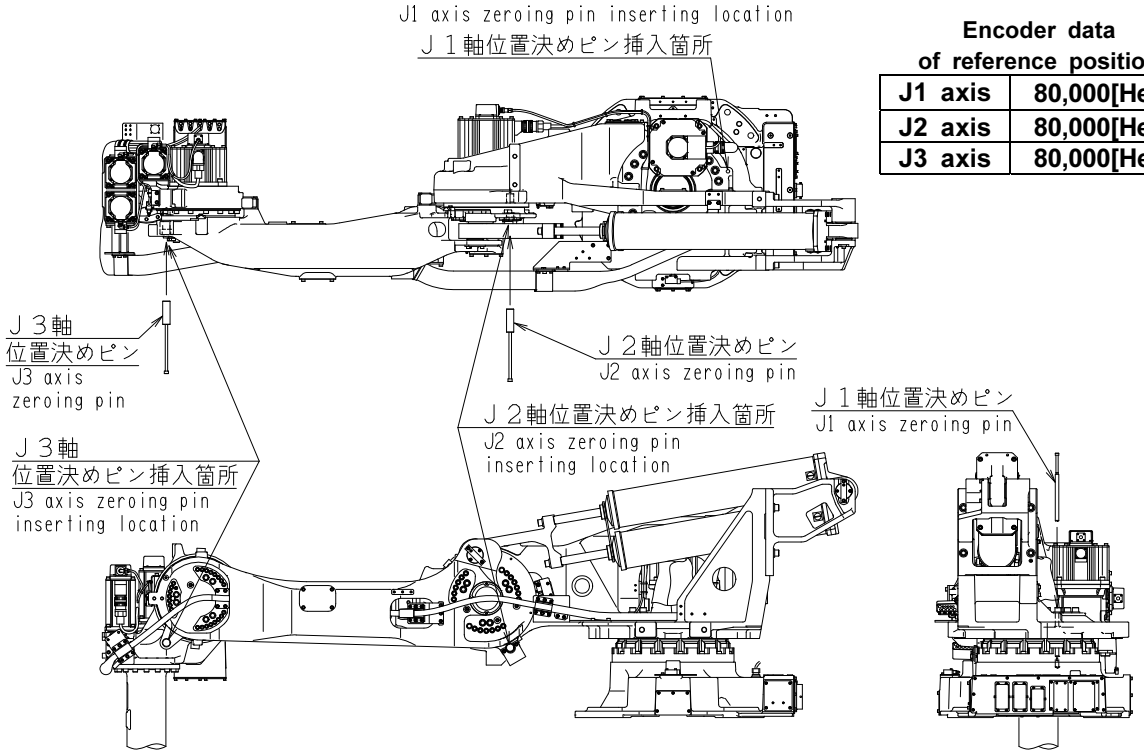


Encoder data of reference position

J1 axis	**80,000[Hex]**
J2 axis	**80,000[Hex]**
J3 axis	**80,000[Hex]**

[ST133TF-01][ST166TF-01][ST210TF-01]

Reference position (Zeroing pin insertion portions) of J1,J2 and J3 axis

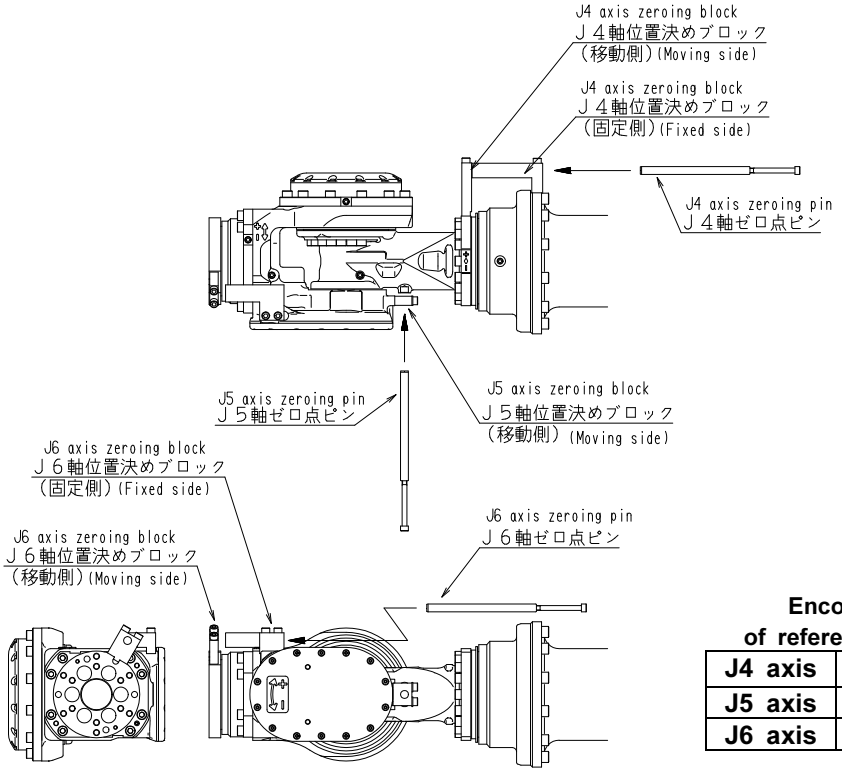


Encoder data of reference position

J1 axis	**80,000[Hex]**
J2 axis	**80,000[Hex]**
J3 axis	**80,000[Hex]**

[ST133F-01][ST166F-01][ST133TF-01][ST166TF-01]

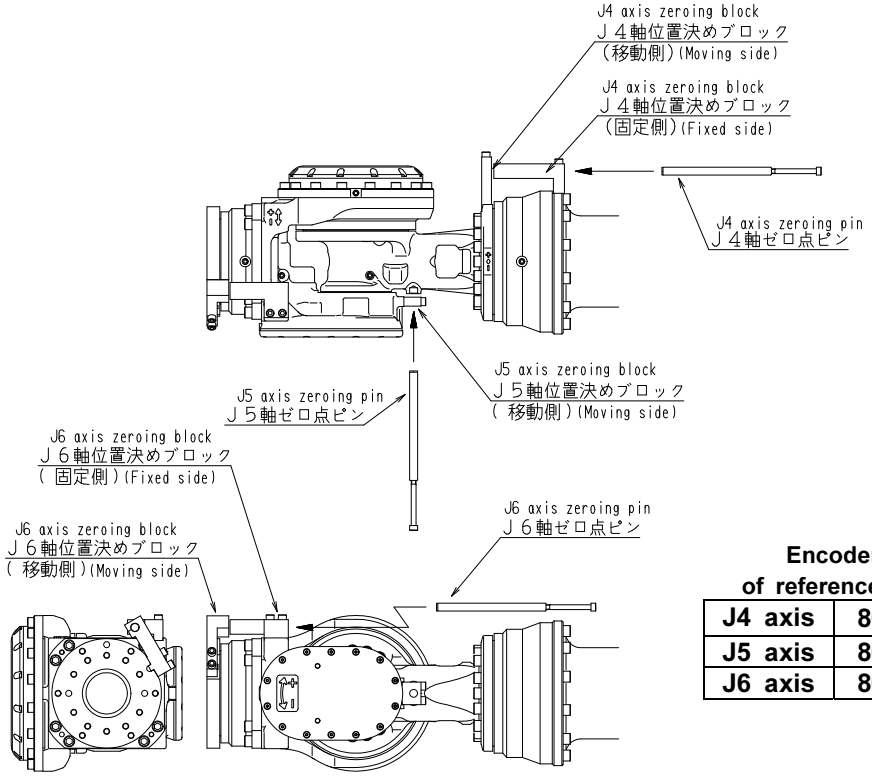
Reference position (Zeroing pin insertion portions) of J4,J5 and J6 axis



Encoder data of reference position

J4 axis	**80,000[Hex]**
J5 axis	**80,000[Hex]**
J6 axis	**80,000[Hex]**

[ST210F-01] [ST210F-01]
Reference position (Zeroing pin insertion portions) of J4,J5 and J6 axis



Encoder data of reference position

J4 axis	**80,000[Hex]**
J5 axis	**80,000[Hex]**
J6 axis	**80,000[Hex]**

CAUTION

In cases where a motor has been damaged while the robot was moving, for instance, it may be necessary to replace the motor and implement encoder reset **at a position where the zeroing pin cannot be inserted**. In such a case, an error may occur during axis operation, making it impossible to move the robot any further. At times like this, robot movement can be resumed by provisionally implementing encoder correction at the position concerned so move the axis to the position where the zeroing pin can be inserted, and proceed with encoder reset and encoder correction again.

WARNING

Some of this work is done while power is supplied to the motor. Therefore, perform pinning in pairs. One person must stand guard and ready to press an emergency stop button. The other person must work quickly and carefully within the robot operating area. An escape route should be determined before starting pinning work. If these actions are neglected, the robot may act incorrectly so that the operator may be caught or sandwiched by the robot parts, possibly resulting in death or serious injury.

CAUTION

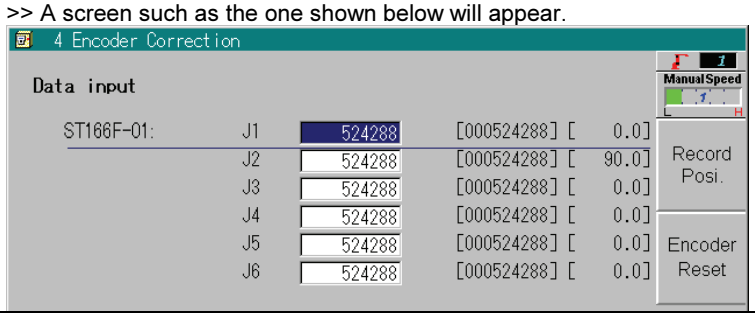
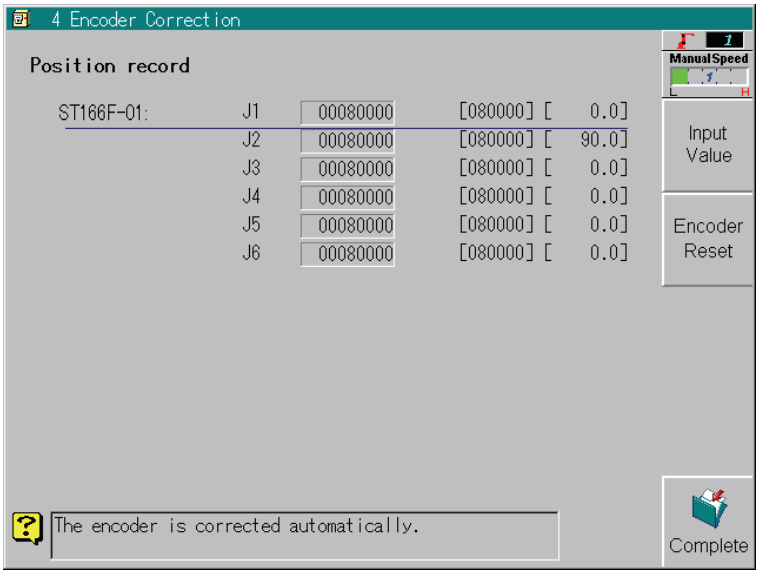
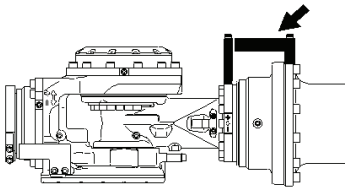
Before performing axis operations, be absolutely sure to remove the zeroing pins. Performing axis operation with the zeroing pins still in place may bend the pins, damage the pin holes or cause other problems. Bear in mind that if any of these problems has arisen, it will no longer be possible to perform encoder correction accurately and corrections will have to be made to the work program.

If “A-TRAC4” is installed on this robot, please refer to;
“MSTEN-219 MAINTENANCE SERVICE MANUAL ST-F-01 Series A-Trac4

Tools required

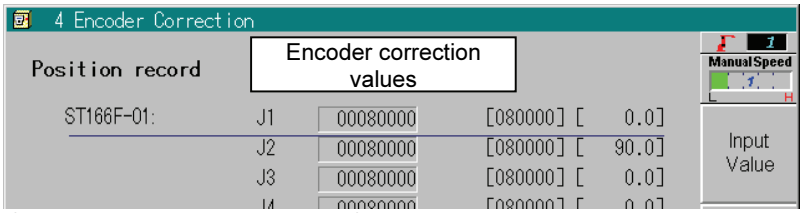
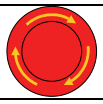
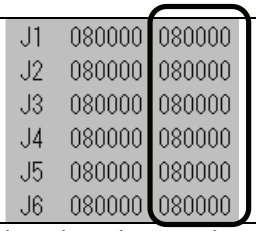
For this procedure, **zeroing pin and block (OP-T2-*** ; option)** is necessary.
Please prepare these tools by referring to 6.2 Special maintenance tools (option).

Encoder correction procedure

	1	Select the [TEACH] mode, and set to the Motors ON state.
	2	Switch the operator qualification to ***Expert***.
	3	Select [Constant Setting] [3 Machine Constants] [4 Encoder Correction]. >> A screen such as the one shown below will appear. 
	4	Press the f8 [Record Posi.] key. >> The screen shown below will now appear. 
	5	**In case of J4,J5 and J6 axis** Prior to inserting zeroing pin, zeroing block must be attached. Remove the covers of zeroing block place, and attach the zeroing blocks using 2 Hex. socket head cap screws (M8). 

CAUTION

Axis interference of wrist axis (J4,J5 and J6 axis)
"Axis interference" exists due to the structure of the wrist on this robot.
For this reason, when performing encoder correction of J5 axis, J4 axis must be in reference position (zeroing pin position). Similarly, when performing encoder correction of J6 axis, J4 and J5 axis must be in reference position (zeroing pin position).
This means that encoder correction must be performed in the sequence of the 4, 5 and 6 axes without fail. If encoder correction has not been performed in this sequence, the zero points of the wrist axes will not be set correctly and the robot will not move properly.

	6	Move the axis at manual speed 2 or 3 to the reference position, and insert the zeroing pin in the pin hole. At this point, the encoder correction value is still incorrect so exercise sufficient caution in operating the robot. Reference position of J1,J2 and J3 axis Refer to p5-21 and p5-22 Reference position of J4,J5 and J6 axis Refer to p5-22 and p5-23
	7	Align the cursor with the axis whose reference position is adjusted (zeroing pin is inserted), press the [ENTER] key followed by the [O.WRITE/REC] key. >> The [Encoder correction value] is now adjusted so that the current machine position will be set as the **encoder data of reference position**.  If encoder correction is required for other axes as well, repeat steps 5) and 6) for the axes concerned.
	8	Upon completion, remove the zeroing pin and zeroing block. In case of J4,J5 and J6 axis, attach the cover which covers the zeroing block attachment points to its original position.
	9	Press the Emergency Stop button to turn OFF the motor power.
	10	Press f12 [Complete]. >> The adjusted encoder correction value is saved in the internal memory. **(Caution)** **Until [Complete] is pressed, the encoder correction value will not be saved into the internal memory. This point should be borne in mind.**
	11	Using [Service Utilities] [2 Monitor 1] [1 Axis Data Monitor], check that the current value of the axes for which encoder correction was performed is **encoder data of reference position**. 

This now completes the encoder correction procedure. After checking that the zeroing pin and zeroing block have been removed, move the axes by operating them manually to check that their movements are problem-free.

5.4.5 More accurate encoder correction

Sometimes normal encoder correction (using zeroing pins and blocks) is not sufficient to recover the taught positions precisely in case that bigger tool is mounted, etc. In such case, modify (re-calculate) the encoder correction value by following procedure after here.

Needed tools;

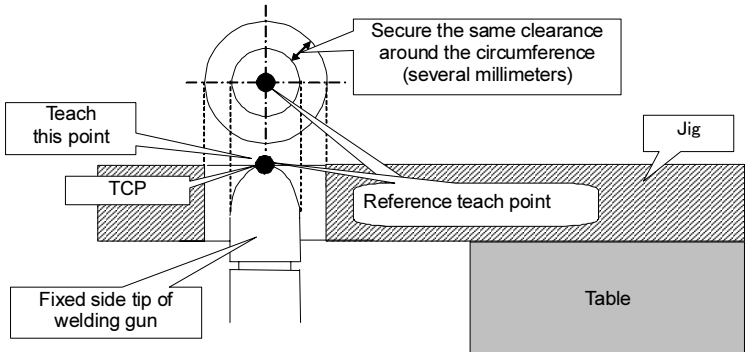
・Jig that is fixed on the ground or on the table for “Reference teach point”
・Calculator (needed to re-calculate the encoder correction)

Preparation

1 **Making a program of “Reference teach point”**

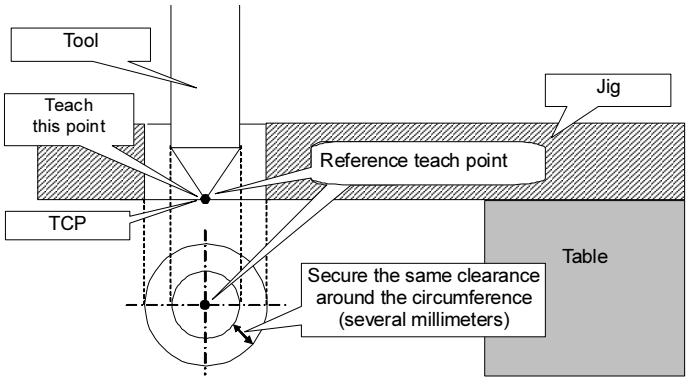
Inside the robot working envelop, install the **jig for “Reference teach point“ that is fixed on the ground or on the table**. Make a program including a step where robot TCP is precisely coincident with the “Reference teach point”. This step is called **“Step of reference teach point”** here in after. This procedure must be done before the work teaching is started.

(Example 1)



Notes: In case of welding gun, precise “Step of reference teach point” can not be obtained when worn tip is used or tip is not fixed sufficiently.

(Example 2)



More accurate encoder correction

CAUTION

In case that motor / encoder is replaced or encoder reset is performed at the same time for plural axis, position recovery by this procedure is very difficult.
This procedure must be performed for only one axis (one by one).

Sample for J1 axis

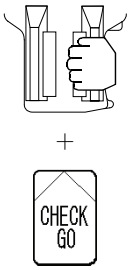
1 **Perform encoder reset and normal encoder correction**

Perform encoder reset and normal encoder correction by following to

"5.4.3 Encoder reset" and

"5.4.4 Encoder correction"

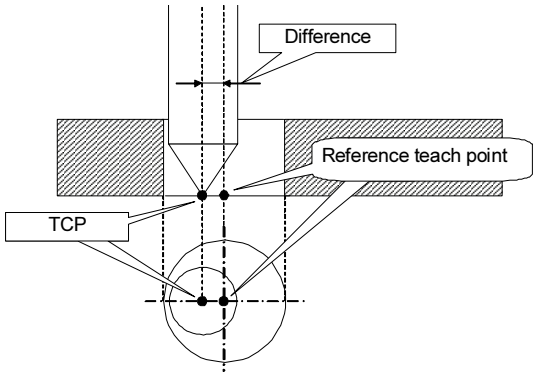
(Before proceeding, switch the operator qualification to ***Expert.***)



2 **Check the difference from "Reference teach point"**

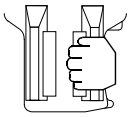
By check GO operation, move the robot to the "Step of reference teach point" and stop the robot in axis coincidence status (cursor line is changed to yellow).

If the difference from TCP and "Reference teach point" does not exceed the permitted level, procedures after here is not needed. If exceeded, encoder correction value of target axis is to be modified by following the procedure after here.



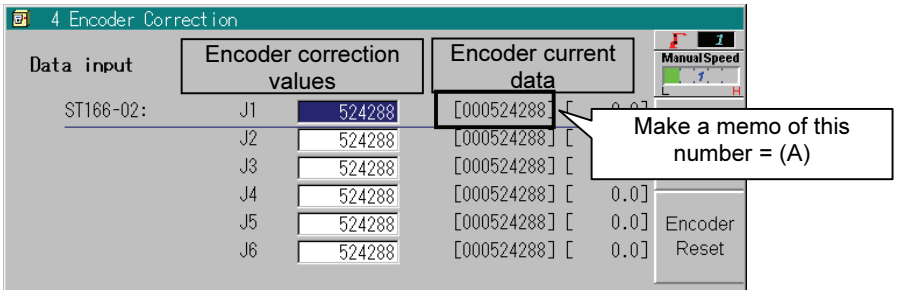
(Caution)

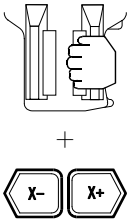
Check GO operation must be started from the position where the interference with the jig will never happen.

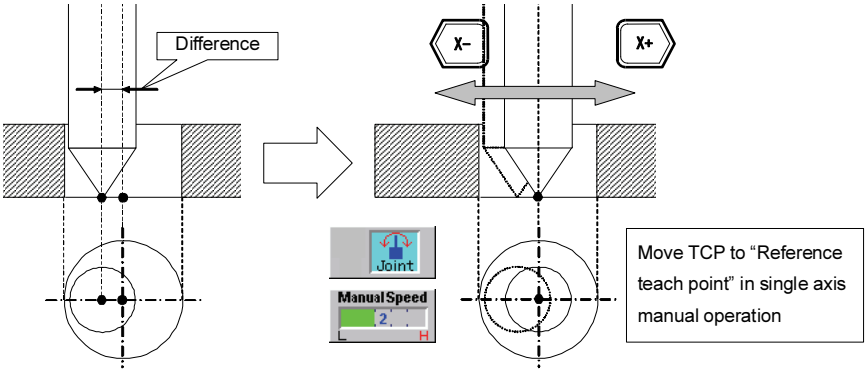


3 **Make a memo of encoder current data (A)**

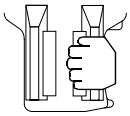
While gripping the enabling switch, open <Constant setting> [3 Machine constants] – [4 Encoder correction]. Then read the "Encoder current data" in [Data input] screen and write a memo of it. This value is assumed as (A).

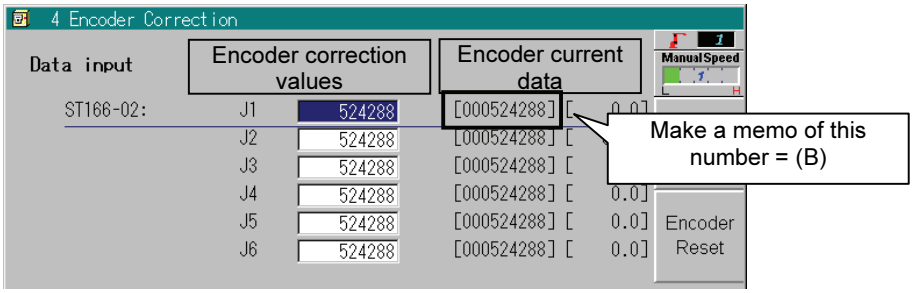


<table>
<tr>
<td> 
</td>
<td>4</td>
<td><u>Move TCP to “Reference teach point” in manual operation</u>

Move the robot by manual operation of <u>single axis that is the target of encoder correction</u> (J1 axis in this explanation) with speed 2 or 3 in order that TCP is coincident with “Reference teach point”.
 

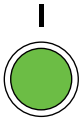
(Supplement)

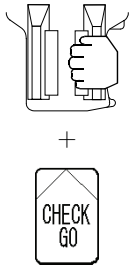
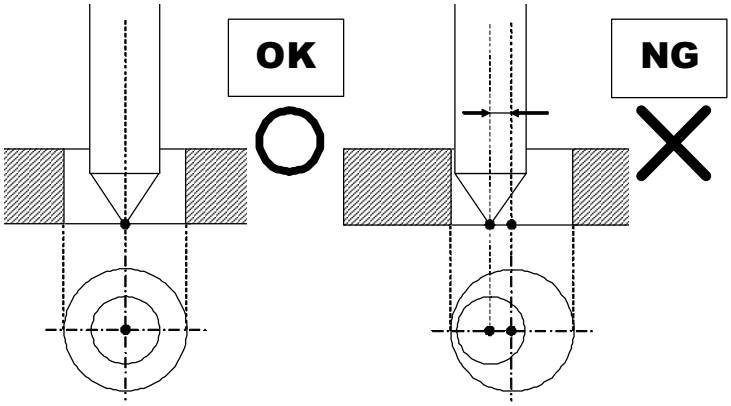
If the axis that does not concern with the target axis was moved by mistake, please retry the procedure from step 2.</td>
</tr>
<tr>
<td>  </td>
<td>5</td>
<td><u>Make a memo of encoder current data (B) after TCP is moved</u>

<u>While gripping the enabling switch</u>, open again <Constant setting> [3 Machine constants] – [4 Encoder correction]. Then read the “Encoder current data” in [Data input] screen and write a memo of it. This value is assumed as (B).
 
</td>
</tr>
<tr>
<td>  </td>
<td>6</td>
<td>Press the Emergency Stop button to turn the motor power OFF.
(After this, enable switch can be released.)</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td><u>Re-calculate the encoder correction value</u>

Calculate

(Encoder correction value) – ((A) – (B))

by calculator and key in the result to the edit box of “Encoder correction values” in same screen. (Utilize the table of next page for convenience.)</td>
</tr>
<tr>
<td> 
</td>
<td>8</td>
<td>Press f12 [Complete].
>> The adjusted encoder correction value is saved in the internal memory.
(Caution)
Until [Complete] is pressed, the encoder correction value will not be saved into the internal memory. This point should be borne in mind.</td>
</tr>
<tr>
<td>  </td>
<td>9</td>
<td>Right turn the Emergency Stop button and turn the motor power ON again.</td>
</tr>
</table>

	10	By check GO operation, move the robot again and confirm that TCP is surely coincident with “Reference teach point”. If not, new encoder correction value calculated in step 7 is wrong. Retry the calculation and registration.  (Supplement) Final aim of this procedure is to get the encoder correction value in order that TCP is coincident with “Reference teach point” with high accuracy. Therefore, it is possible that, Instead of step 2 to 6, changing (adjusting) the encoder correction value manually little by little while visually checking the TCP position.
	11	If necessary, try check GO operation of work program and confirm the positioning accuracy of taught points.

(Reference) Utilize this table to calculate encoder correction

Axis	Encoder current data where TCP is not coincident with “Reference teach point” (A)	Encoder current data after moved (where TCP is coincident with “Reference teach point”) (B)	Original encoder correction value (C)	Re-calculated encoder correction value (C)-((A)-(B))
J1				
J2				
J3				
J4				
J5				
J6				

Register this value as the new encoder correction value

(Example)

Axis	Encoder current data where TCP is not coincident with “Reference teach point” (A)	Encoder current data after moved (where TCP is coincident with “Reference teach point”) (B)	Original encoder correction value (C)	Re-calculated encoder correction value (C)-((A)-(B))
J1	522027	522017	520249	520249 - (522027 - 522017) = 520239

5.5 Encoder replacement

Since this robot is of encoder separation type on all axes, the encoder is replaceable. With the encoder assembled in the robot, however, the assembly jig may not be inserted depending on the robot configuration. In this case, referring to information in “5.4 Motor Replacement”, replace the whole motor unit. The following section describes the replacement procedure when the robot is configured so that the encoder can be replaced.

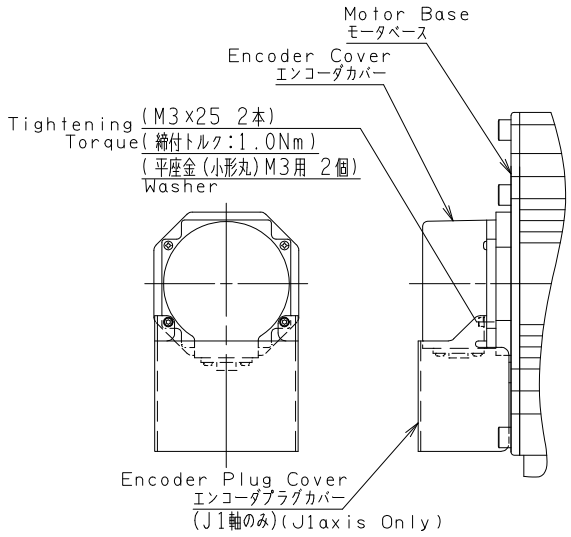
Tools required

Part name	Axis name	Part No. (Model)	Remark
Torque screwdriver	J1 axis	M3 torque wrench	
	All axes	M3 torque screwdriver	*1, *2
		M3 setscrew torque screwdriver	*1, *3
Locking agent		Threebond 1374	

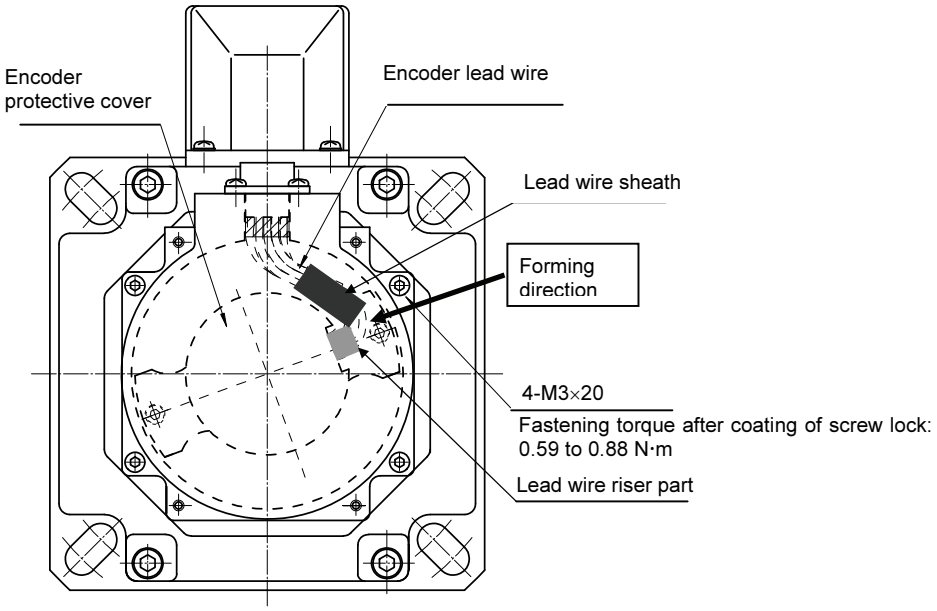
(Prepared by customer)

*1 Use a commercially-available torque screwdriver. (Screw driver, which meets the fastening torque of 0.59 to 0.88 N·m.)
*2 Used for mounting of the encoder cover and the encoder fixing spring
*3 Used for mounting of encoder boss part (for set screws)

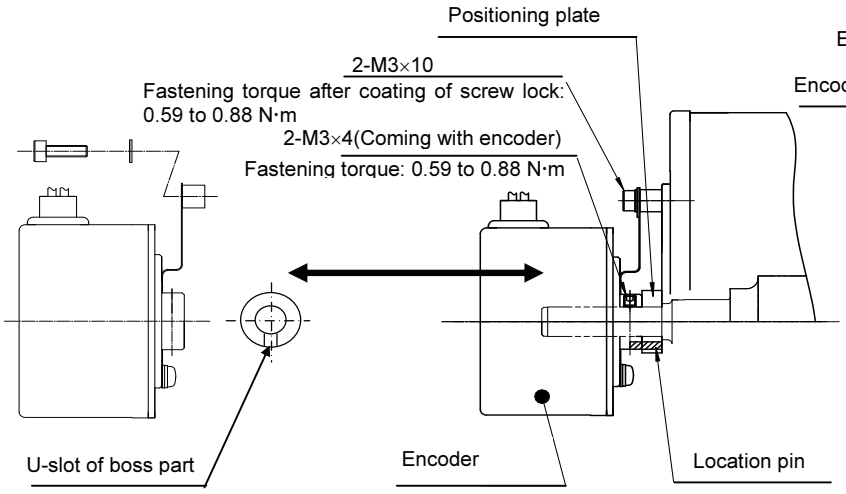
Encoder replacement procedure (common for all axes)

STEP	Work performed	Checkpoints
1	Turn ON the primary power of the controller, select the TEACH mode, and select Motors ON.	If Motors ON cannot be operated or axis operations cannot be performed due to an abnormality, start the procedure from step 3.
2	If axis operations can be performed, refer to “5.4.4 Encoder correction” to proceed with the axis operation to the position where the zeroing pin can be inserted, and to insert the zeroing pin.	The work to be performed after encoder replacement is made easier if the zeroing pins are inserted ahead of time.
3	After making Motors OFF status, turn OFF the primary power supply of the controller.	
4	Disconnect the encoder connectors.	
5	Remove two encoder plug cover (only J1 axis) (J2,J3 axes are option). Refer the following drawing. J1 **2-M3X25**  	

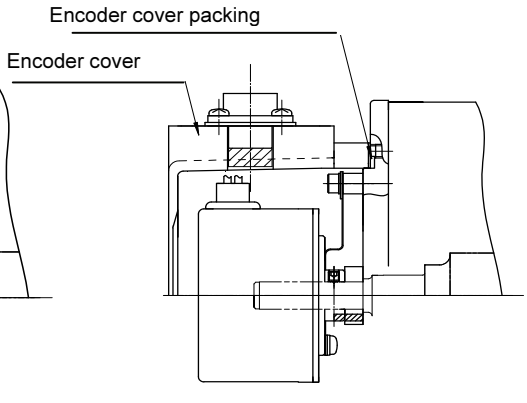
6	Dismount the encoder from the motor. (a) Dismount the encoder cover removing the following bolts. J1 axis only **2-M3X20** J2 to J6 axes **4-M3X20** (b) Remove the two bolts that fix the encoder fixing spring. **2-M3X10** (c) Remove the two set screws that fix the encoder boss part, and then pull out the encoder assembly from the motor shaft. **2-M3X4**	At this time, dismount the encoder cover in order not to cause tension to the encoder lead wire.



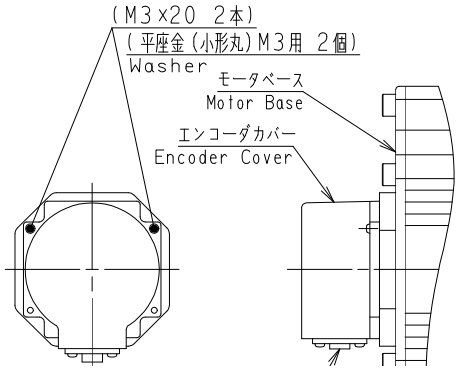
Outline figure of encoder



Dismounting of encoder unit



Cross-section of encoder cover

STEP	Work performed	Checkpoints
7	Referring to the figures in the previous page, fix the encoder to the motor. (a) Insert the encoder so that the U-slot of the encoder boss part is aligned with the zeroing pin on the motor side. (b) Insert the encoder until the encoder boss part hits the positioning plate of the motor shaft, and then torque the set screws of the boss part **2-M3X4 (tightening torque: from 0.59 to 0.88 N·m)** (c) Fix the encoder fixing spring by the following 2 bolts. **2-M3X10 (tightening torque: from 0.59 to 0.88 N·m)** (d) Form the lead wire riser part so that the encoder lead wire will follow the outer circumference of the protective cover. Then, with the sheath of the lead wire pulled to the riser part, put the encoder cover in place. After that, torque the following bolts. To refer the bolt position, see the following figure and the figure in the previous page. J1 axis only **2-M3X20 (tightening torque: from 0.59 to 0.88 N·m)** J2 to J6 axes **4-M3X20 (tightening torque: from 0.59 to 0.88 N·m)**  Attach the removed encoder plug cover (only J1 axis) (J2, J 3 axis are option) to the new motor, referring to the STEP5. J1 axis Attach encoder plug cover with following bolts. **2-M3 X 25 (tightening torque: 1.0 N·m)** **2-flat washers (small/round) for M3 (used from the beginning)**	Clean the shaft and the installation surface carefully in advance. For this purpose, be sure to use the new setscrews with screw lock that come with the encoder. Apply one or two drips of screw lock (THREEBOND 1374) to the bolts. • At this time, apply one or two drips of locking agent (THREEBOND 1374) to the bolts. • At this time, put the encoder packing in place.
8	Connect the connector to the encoder.	
9	Reset the encoder on the axis, the encoder of which was replaced, referring to information in “5.4.3 Encoder reset”.	
10	Reset the encoder on the axis, the encoder of which was replaced, referring to information in “5.4.4 Encoder correction”.	
11	Check to be sure that the robot has no problem with the movement.	

Now completes the encoder replacement.

5.6 Wrist unit replacement

WARNING

This replacement work must be done by persons who received special maintenance training.

WARNING

The replacement work should be done by confirming the safety of the environment and securing escape route or area to avoid dangers in advance.

WARNING

For works e.g. daily inspection, repair, parts replacement, etc., be sure to turn OFF the power of the robot controller in advance. And, to prevent other workers from turning ON the power supply carelessly, put a warning sign like "**DO NOT POWER ON**" around the primary power switch etc.

WARNING

Use spare parts designated in the maintenance manuals. For details, controller maintenance manual and robot maintenance service manual.

WARNING

When replacing the wrist unit, do not forget to fix the arm in advance. Refer to "5.4 Motor replacement" for reference.

CAUTION

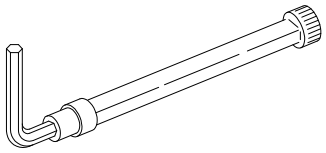
To touch the robot immediately after it stops, check to be sure that the robot is not hot, and then touch it with care. The wrist unit mass is listed in the table below. Consequently, handle the wrist unit with care.

Robot type	Wrist unit mass
ST133F-01, ST166F-01, ST133TF-01, ST166TF-01	50 kg
ST210F-01, ST210TF-01	77 kg

Tools required

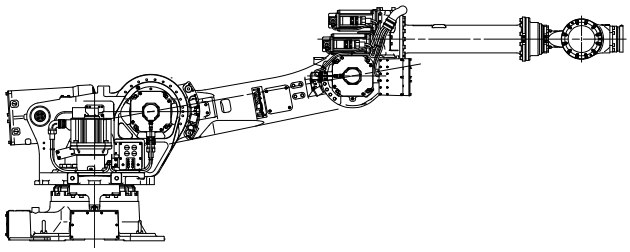
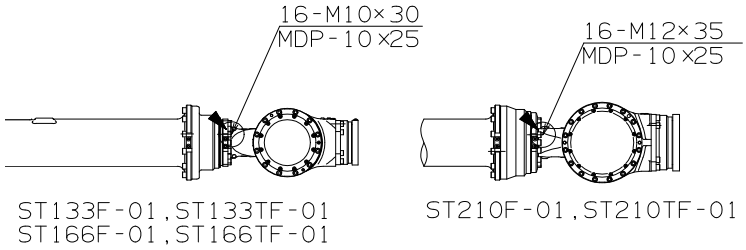
Part name	Part No. (Model)	Remark
Torque wrench (prepared by customer)	M12 torque wrench (L type torque wrench)	*1, *2
	M10 torque wrench (L type torque wrench)	*1, *3
	M10 torque wrench	*4
	M8 torque wrench	*5
Locking agent	ThreeBond 1374	
Grease	LONGTIME PD2	Compatible grease; ALVANIA RA

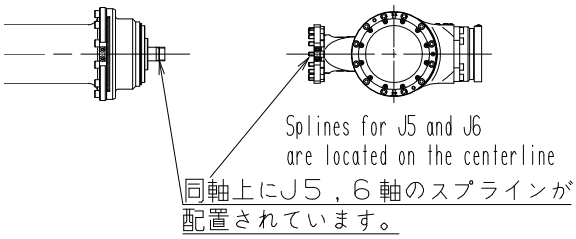
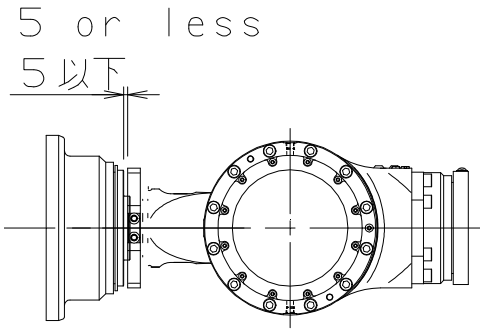
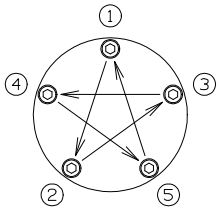
*1 Use a commercially-available long wrench or extension wrench. (right figure)
*2 for ST210F-01 and ST210TF-01 wrist unit replacement
*3 for ST133F-01, ST133TF-01, ST166F-01, and ST166TF-01 wrist unit replacement
*4 Used for replacement of tools e.g. welding gun, gripper, etc.
*5 Used for installing zeroing blocks



L type torque wrench

Wrist unit replacement procedure

STEP	Work performed	Checkpoints
1	Set the wrist axes (J4, J5, and J6) to zero degree position referring to “5.4.4 Encoder correction” and then set J3 axis to horizontal angle. (See the following figure)	If Motors ON cannot be operated or axis operations cannot be performed due to an abnormality, start the procedure from step 2.
		
2	Turn OFF the Motors, and then turn OFF the controller primary power.	
3	Dismount the loads (welding gun, hand, or work-piece etc.) from the wrist unit.	Concerning the wrist flange, see “1.5 Details of wrist mounting section”.
4	Remove the wrist unit installation bolts and locating pin. And then dismount the wrist unit from the robot.	Wrist unit is heavy. Be careful.
		

	Apply grease (LONGTIME PD2) on all the splines of the forearm side and the new wrist unit side until the gaps of them are filled with the grease. **(4 portions)**	Although ALVANIA RA grease is applied on the gears, LONGTIME PD2 can be applied there because it has the same lithium soap base and the same consistency with ALVANIA RA.
5		
6	Mount a new wrist unit onto the forearm. (See following figure) If the gap between the forearm and the wrist unit is 5mm or less, the splines match each other. (a) Temporally attach the wrist unit using the following bolts. **ST133F/166F-01 ST133TF/166TF-01 16XM10X30** **ST210F/210TF-01 16XM12X35** (b) Locate the position of the wrist unit using locating pin. **(All models) MDP-10×25** (c) Tighten the bolts completely with the following rated torque to mount the wrist unit. **ST133F/166F-01 ST133TF/166TF-01** **16×M10X30 (TIGHTENING TORQUE 67.0Nm)** **ST210F/210TF-01** **16×M12X35 (TIGHTENING TORQUE 116Nm)** 	• If O-ring is damaged, replace it. ST133F/166F-01 ST133TF/166TF-01 C00552A ST210F/210TF-01 C00548A • Do not tighten the bolts forcibly unless the splines match each other. If the bolts are tightened forcibly when the splines do not match each other, those splines will be broken. • At this time, apply locking agent (ThreeBond 1374) of 1 or 2 drops onto the bolts in advance.. • Be absolutely sure to use the torque wrench to attach the bolts. Then tighten bolts gradually & uniformly using a torque wrench. 
7	Refer to “5.4.4 Encoder correction” to proceed with the encoder correction.	• If a wrist unit has been replaced in a posture that prevents the zeroing pin from being inserted, proceed with encoder reset and encoder correction to enable axis operation, and then once more move the axis to the position where the zeroing pin can be inserted, and proceed with encoder reset and encoder correction again.
8	Ensure that the robot operation presents no problem.	

This now completes the wrist unit replacement.

Notes

Chapter 6 Recommended spare parts

6.1 Recommended Spare Parts

Recommended spare parts are listed in the following table. To purchase any spare parts, check the robot for the Manufacturing number and the Date of manufacture, and then contact our Service Department.

Classification A: Periodical maintenance parts B: Spare parts

[Table6.1-1] Recommended spare parts

Classification	Name	Part No. (Model)	In use/unit	Recommended/unit	Robot model						Remark
					ST133F-01	ST133TF-01	ST166F-01	ST166TF-01	ST1210F-01	ST210TF-01	
A	GREASE	PM/W-16KG	—	1	○	○	○	○	○	○	MOLYWHITE RE No. 00
A	GREASE	LONGTIME-PD2-18KG	—	1	○	○	○	○	○	○	LONGTIME PD2
A	BATTERY	ER17/50H	4	4	○	○	○	○	○	○	Refer to 4.3 Battery replacement for the replacement period (*1)
A	BATTERY UNIT	KP-ZA-011	1	1	○	○	○	○	○	○	
A	COVER SET	SP-CS-003	1	1	○	○	○	○	○	○	0.13m 1 set
A	COVER SET	SP-CS-004	1	1	○	○	○	○	○	○	J1 axis
B	AC SERVO MOTOR	MFMA452D5V3	2	1	○ J1,2,3	○ J1,3	○ J1,2,3	○ J1,3	○ J1,3	○ J1,3	J1,(J2,) J3 axes
B	AC SERVO MOTOR	MFMA552D4V3	1	1		○		○	○	○	J2 axis
B	AC SERVO MOTOR	MSMA302D7V3	3	1	○	○	○	○	○	○	J4, J5, J6 axes
B	ENCODER	DVOP3560	6	1	○	○	○	○	○	○	all axes
B	COUPLING GEAR SET	KP-ZH-109	1	1			○	○	○	○	J1 axis
B	COUPLING GEAR SET	KP-ZH-110	1	1	○	○					
B	COUPLING GEAR SET	KP-ZH-114	1	1	○	○					J2 axis
B	COUPLING GEAR SET	KP-ZH-115	1	1			○	○			
B	COUPLING GEAR SET	KP-ZH-116	1	1					○	○	
B	COUPLING GEAR SET	KP-ZH-111	1	1	○	○					J3 axis
B	COUPLING GEAR SET	KP-ZH-112	1	1			○	○			
B	COUPLING GEAR SET	KP-ZH-113	1	1					○	○	
B	COUPLING GEAR SET	KP-ZH-117	1	1	○	○	○	○	○	○	J4 axis
B	COUPLING GEAR SET	KP-ZH-118	2	1	○	○	○	○	○	○	J5, J6 axes
B	WRIST UNIT	SP-W1-044	1	1	○	○					
B	WRIST UNIT	SP-W1-045	1	1			○	○			
B	WRIST UNIT	SP-W1-046	1	1					○	○	
B	BJ1 UNIT ASSY	SP-BJ1-112	1	1	○	○	○	○	○	○	All wiring integrated type
B	SEAL	037-0572-000	1	1	○	○	○	○	○	○	Sheet packing for battery unit fitting plate

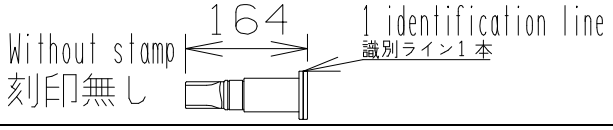
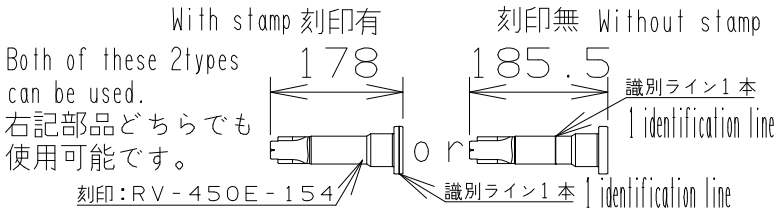
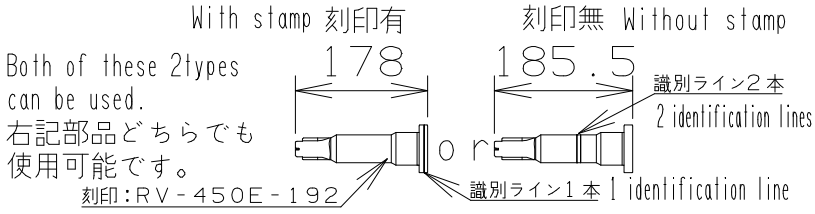
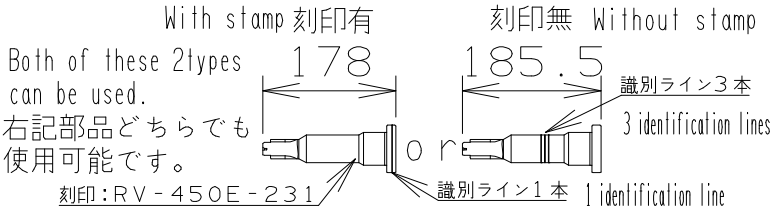
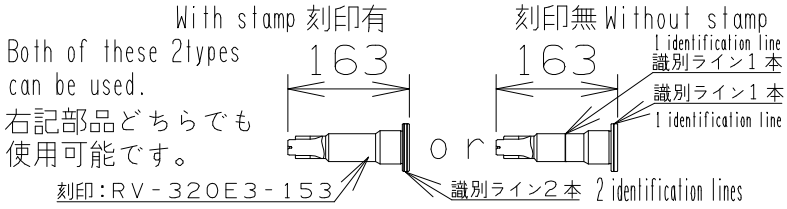
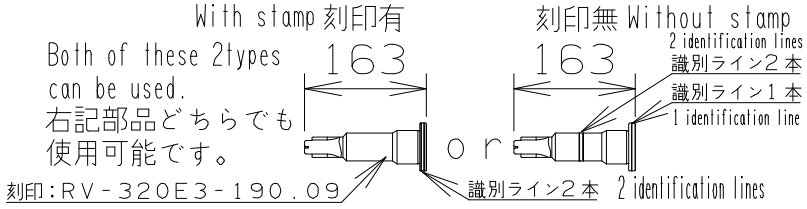
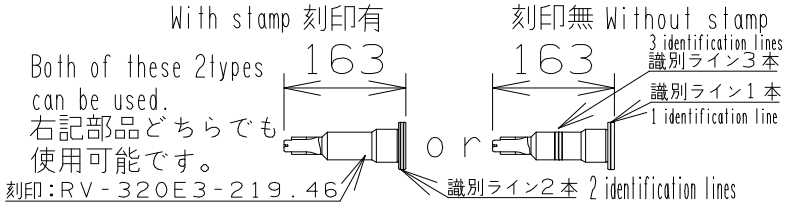
(*1) When replacing the all batteries, please choose battery unit KP-ZA-011(4pcs.spec.) KP-ZA-003 (7pcs.spec.) can be used in the same way.

<Reference 1>

Seals listed below are already included in COUPLING GEAR SET and or so. Please refer them to order individually.

COUPLING GEAR SET of J1 axis → SEAL 037-0623-000 (motor flange)
COUPLING GEAR SET of J2, J3 axes → SEAL 037-0566-002 (motor flange)
COUPLING GEAR SET of J4, J5, J6 axes→ O RING ROA-043 and CO0554A (motor flange)
WRIST UNIT → O RING CO0552A and CO0548A（J4 axis reduction gear）

<Reference 2>
The following figures show the gears that are included in the coupling gear sets for J1,J2 and J3 axes. Please refer to this table to identify the gear type.

Part No. (axis)	Gear shape
KP-ZH-109 (J1)	
KP-ZH-110 (J1)	
KP-ZH-114 (J2)	
KP-ZH-115 (J2)	
KP-ZH-116 (J2)	
KP-ZH-111 (J3)	
KP-ZH-112 (J3)	
KP-ZH-113 (J3)	

6.2 Special tools for maintenance (option)

The fixtures listed below are required fixture for maintenance work or for efficient work.

When purchasing these tools, please contact to your local service center while confirming the robot manufacturing no. and manufactured date.

[Table 6.2-1] Special tools for maintenance (option)

Name	Part No. (Model)	Robot model						Remark
		ST133F-01	ST133TF-01	ST166F-01	ST166TF-01	ST1210F-01	ST210TF-01	
ACCESSORY	OP-T2-040	○	○	○	○			Zeroing pin & zeroing block (Common with ST100/70L)
ACCESSORY	OP-T2-054					○	○	Zeroing pin & zeroing block
H-AXIS FIX JIG	KP-ZD-004	○		○		○		J2 axis Fixing jig set
MAINTENANCE TOOL	KP-ZJ-006	○	○	○	○	○	○	J3 axis Fixing jig set
CONTROLLER	BCUNIT20-20	○	○	○	○	○	○	Bypass cable unit

[Table 6.2-2] Contents of OP-T2-*** (Zeroing pin & zeroing block) (option)

Applied Robot model	Name	Marking	Appearance, etc
All model	J1,J4,J5,J6 Zeroing pin		
All model	J2,J3 Zeroing pin		
All model	J4 fixed side Zeroing block	ST J4	
	J4 moving side Zeroing block	ST J4	
	J5 moving side Zeroing block	ST/SB J5	
	J6 fixed side Zeroing block	SF133 J6	
ST133F,ST133TF,ST166F,ST166TF	J6 moving side Zeroing block	SF133 J6	
ST210F, ST210TF	J6 moving side Zeroing block	SF200F J6	
All model	J4 fixed side fixing bolt		Hex. socket head cap screw 2-M8X60
	J4 moving side fixing bolt		Hex. socket head cap screw 2-M8X100
	J5 moving side fixing bolt		Hex. socket head cap screw 2-M8X40
All model	J6 fixed side fixing bolt		Hex. socket head cap screw 2-M8X45
ST133F,ST133TF,ST166F,ST166TF	J6 moving side fixing bolt		Hex. socket head cap screw 2-M8X55
ST210F, ST210TF	J6 moving side fixing bolt		Hex. socket head cap screw 2-M8X35

The tightening torque for M8 bolt is 33.3 N•m

NOTE

Chapter 7 Wiring Diagrams

7.1 Parts Layout

[ST33F-01] [ST166F-01] [ST210F-01]

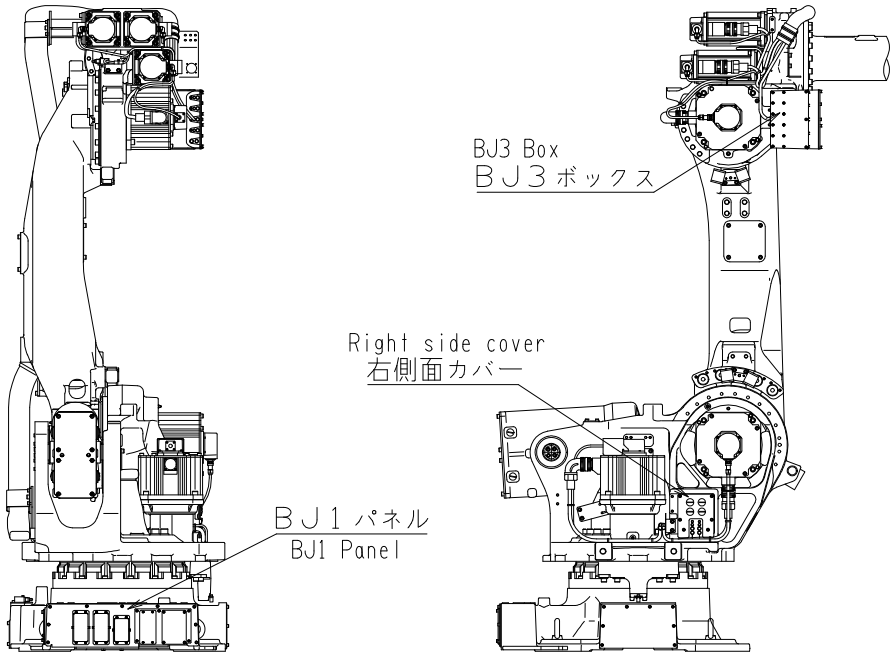


Fig. 7.1-1 Robot Parts Layout

[ST33TF-01] [ST166TF-01] [ST210TF-01]

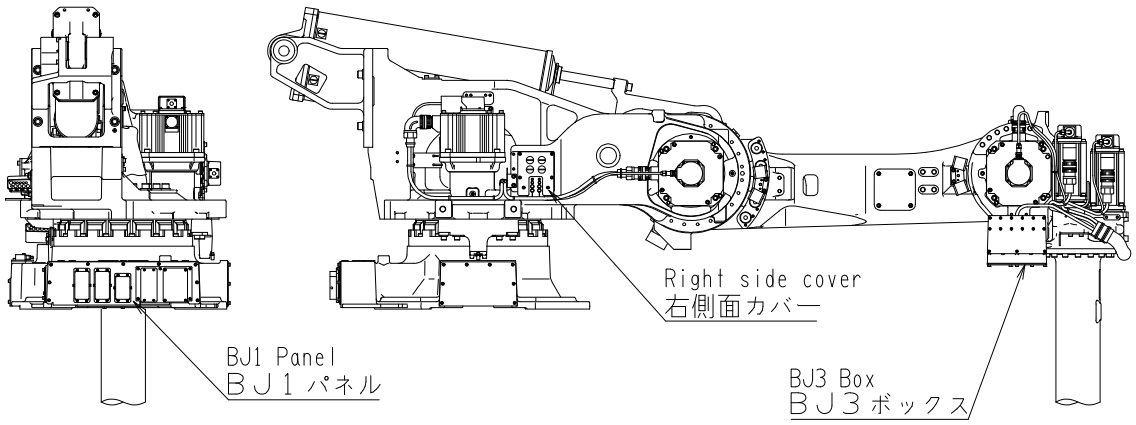


Fig. 7.1-2 Robot Parts Layout

[ST133F-01][ST166F-01][ST210F-01][ST133TF-01][ST166TF-01][ST210TF-01]

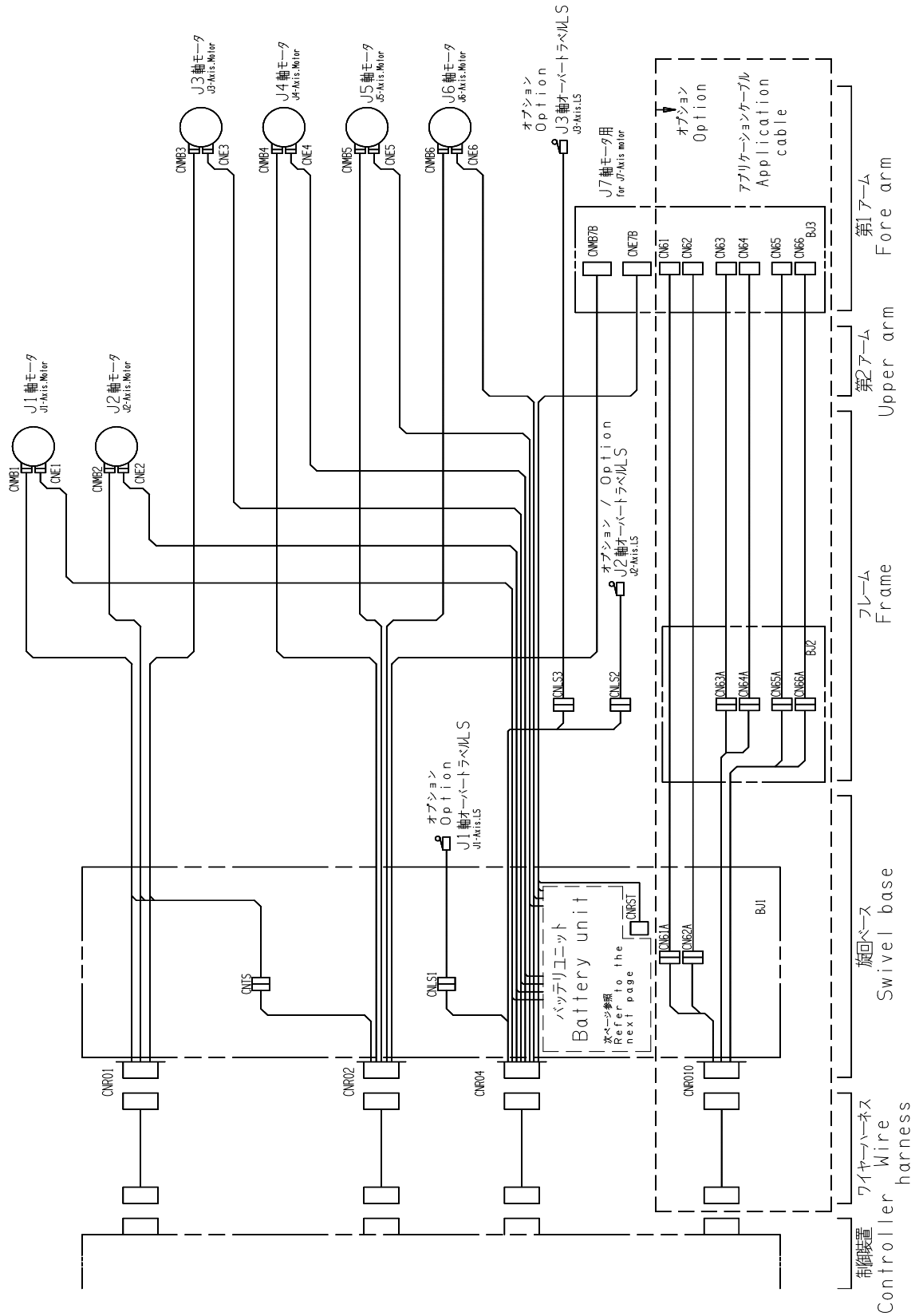
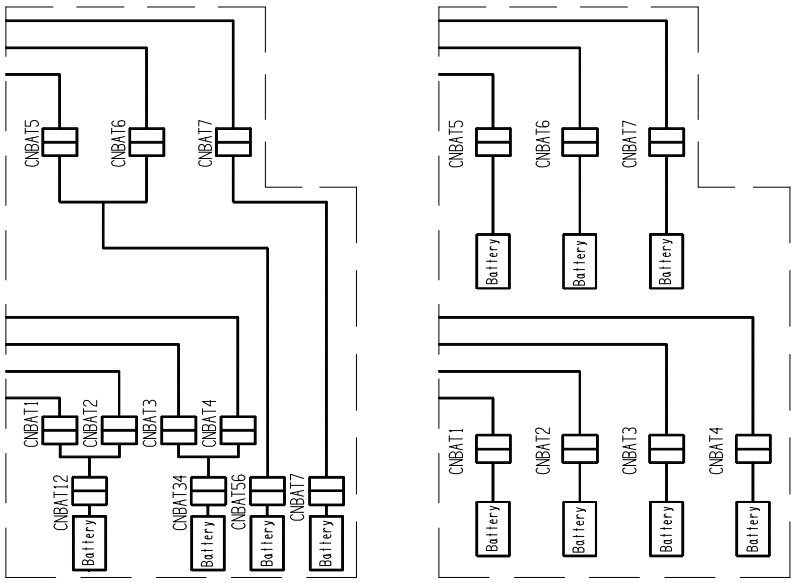


Fig. 7.1-3 Wiring/piping expansion and connection diagram



KP-ZA-011(4 pcs. spec.)　　KP-ZA-003 (7 pcs. spec.)

Fig. 7.1-3 Details of battery units

7.2 Wire Connection Diagrams

For the internal wiring, wire connection diagrams by unit are available. Make use of these diagrams for wiring checks or replacement.

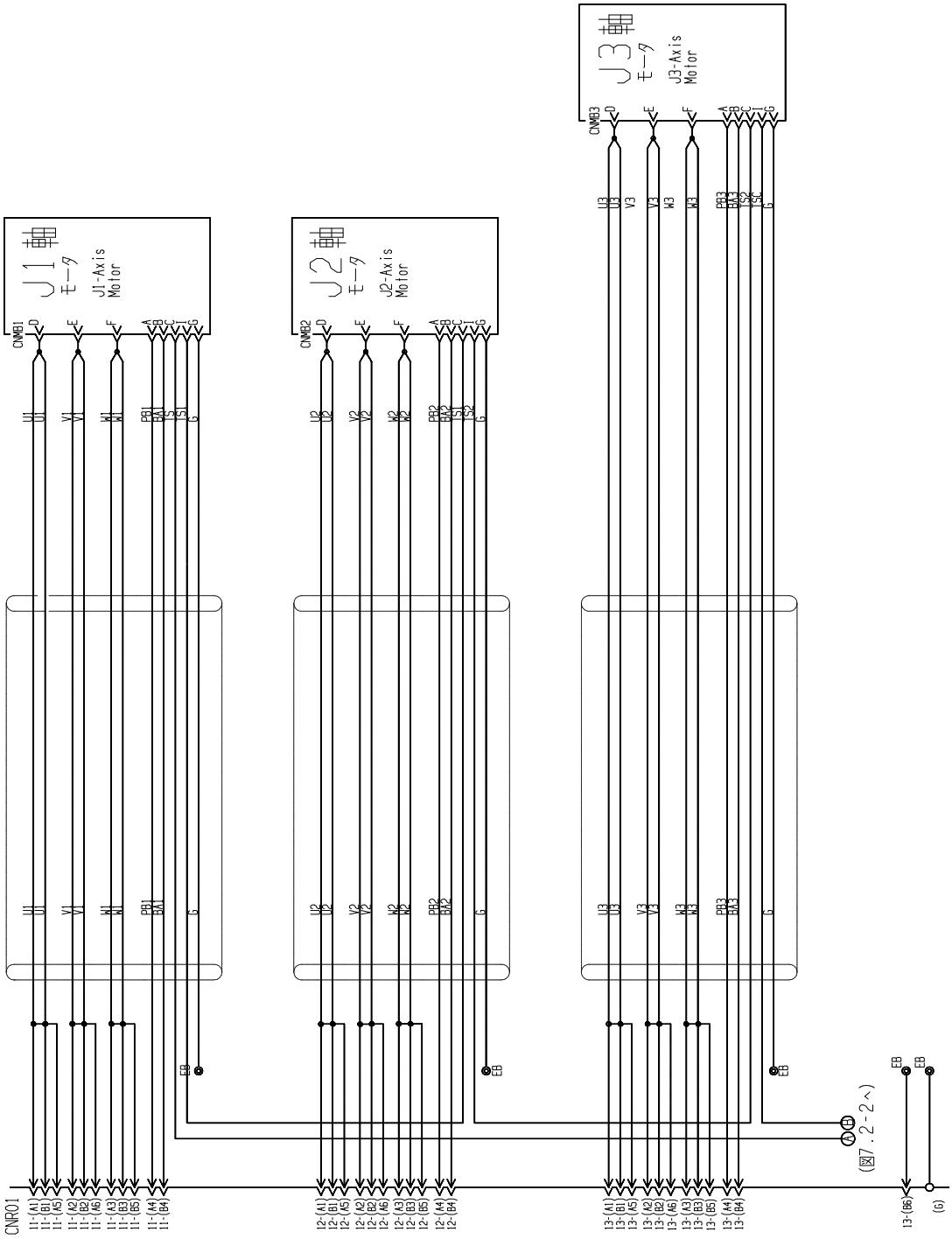


Fig. 7.2-1 Wire Connection Diagram for Motor and Brake 1

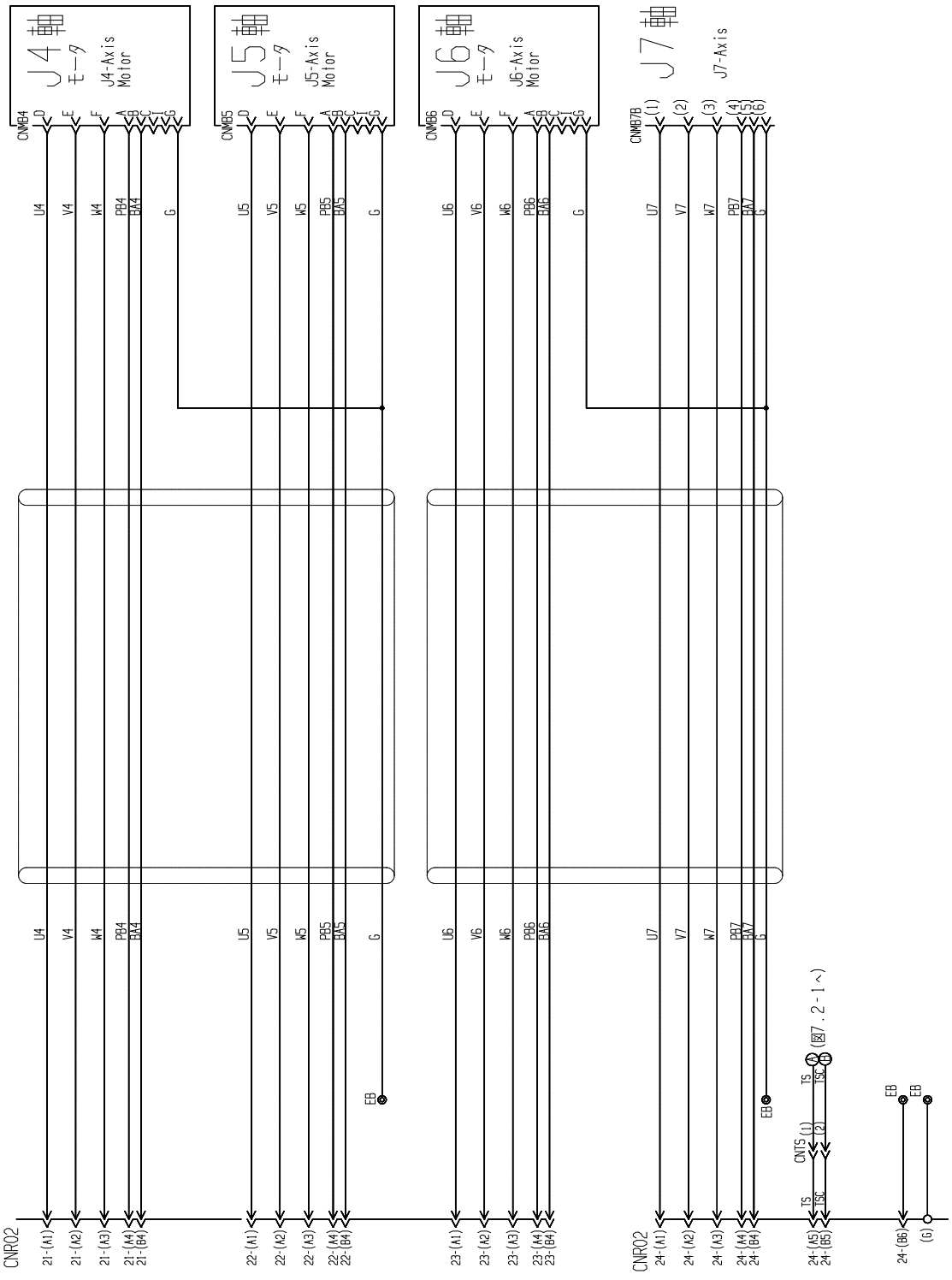


Fig. 7.2-2　Wire Connection Diagram for Motor and Brake 2

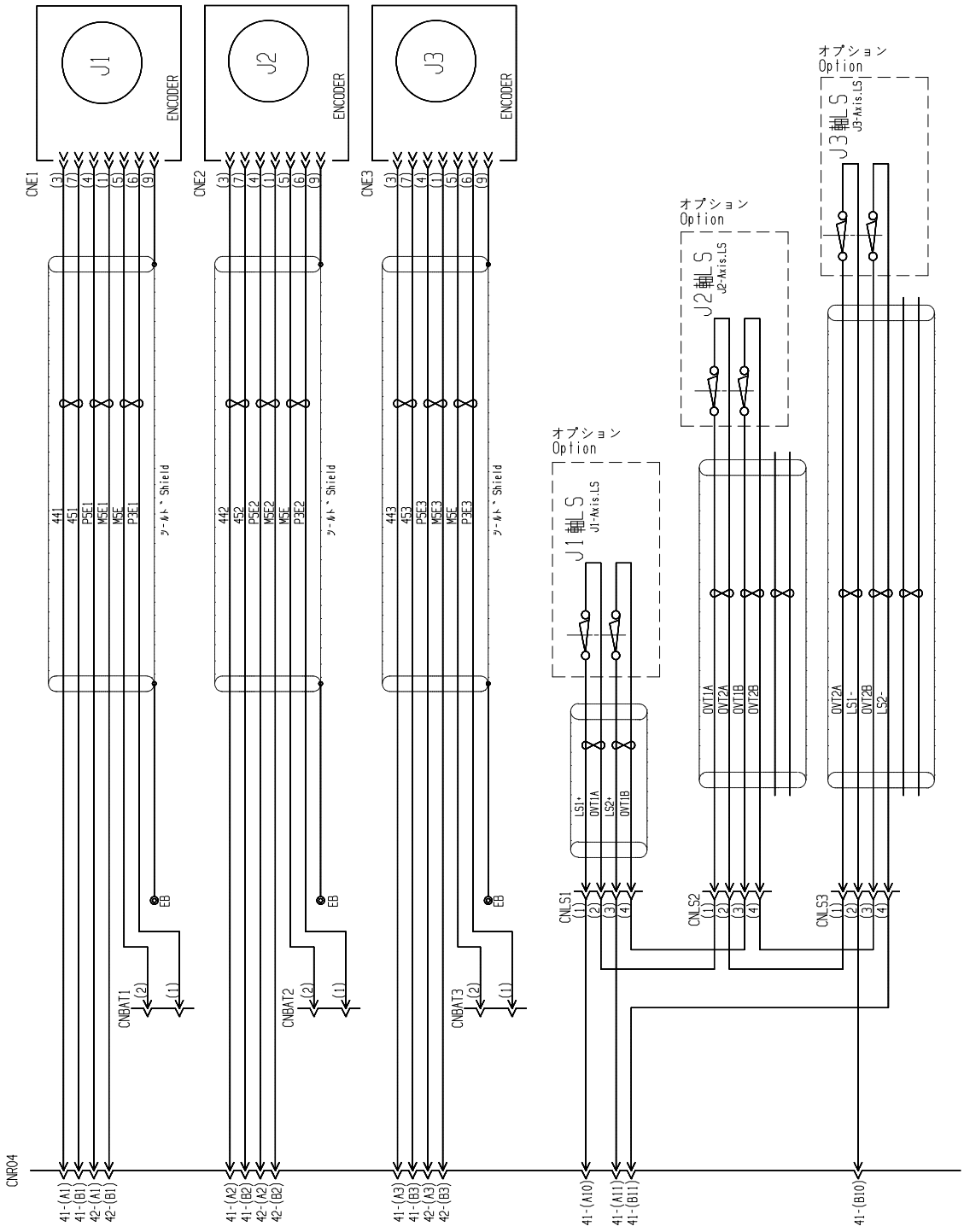


Fig. 7.2-3　Wire Connection Diagram for Encoder 1

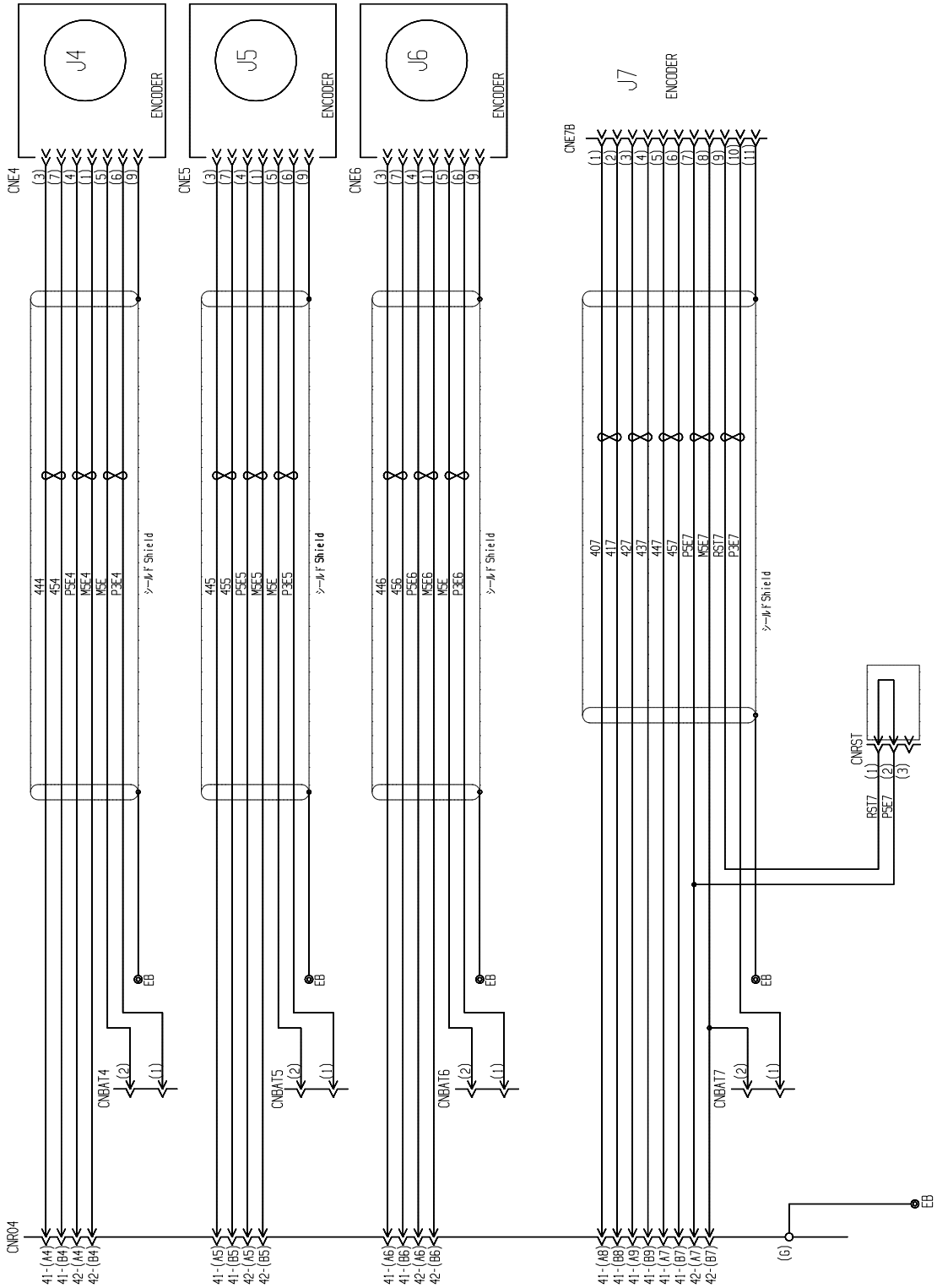
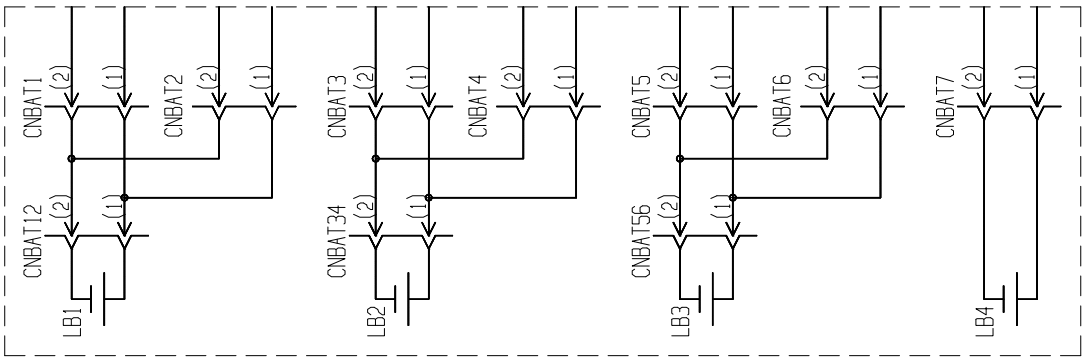


Fig. 7.2-4　Wire Connection Diagram for Encoder 2

4個仕様 / 4 pcs. specification



7個仕様 / 7 pcs. specification

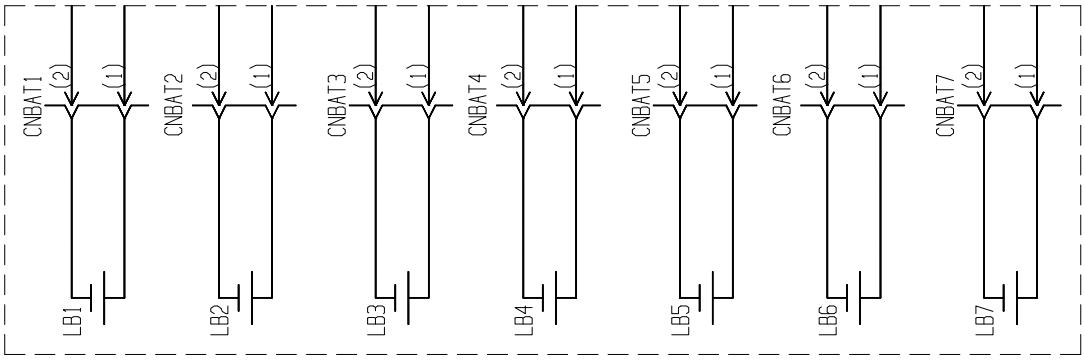
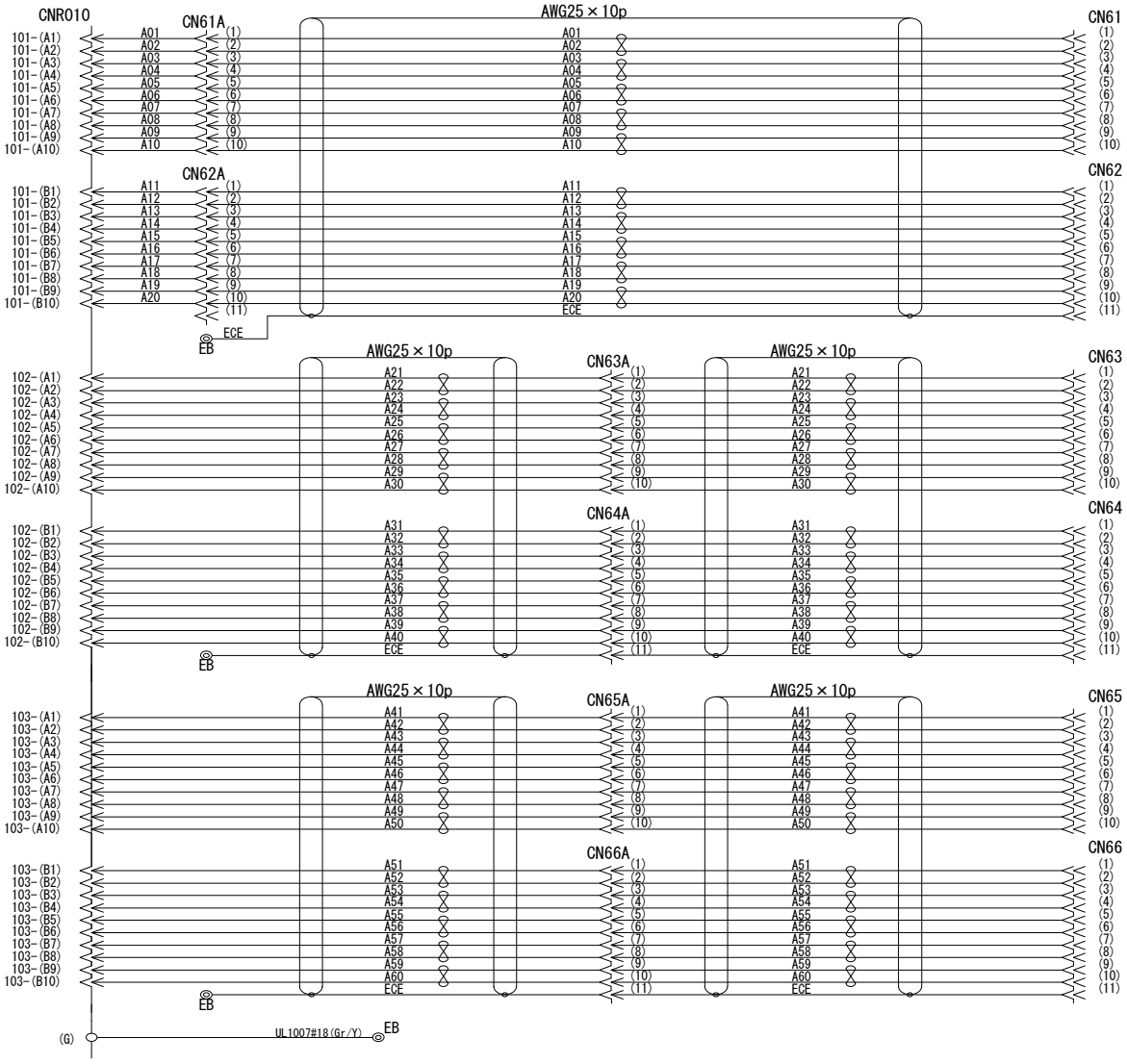


Fig. 7.2-5 Battery connection



The application wirings vary with the specifications.

Fig. 7.2-6　Wire Connection Diagram for Application

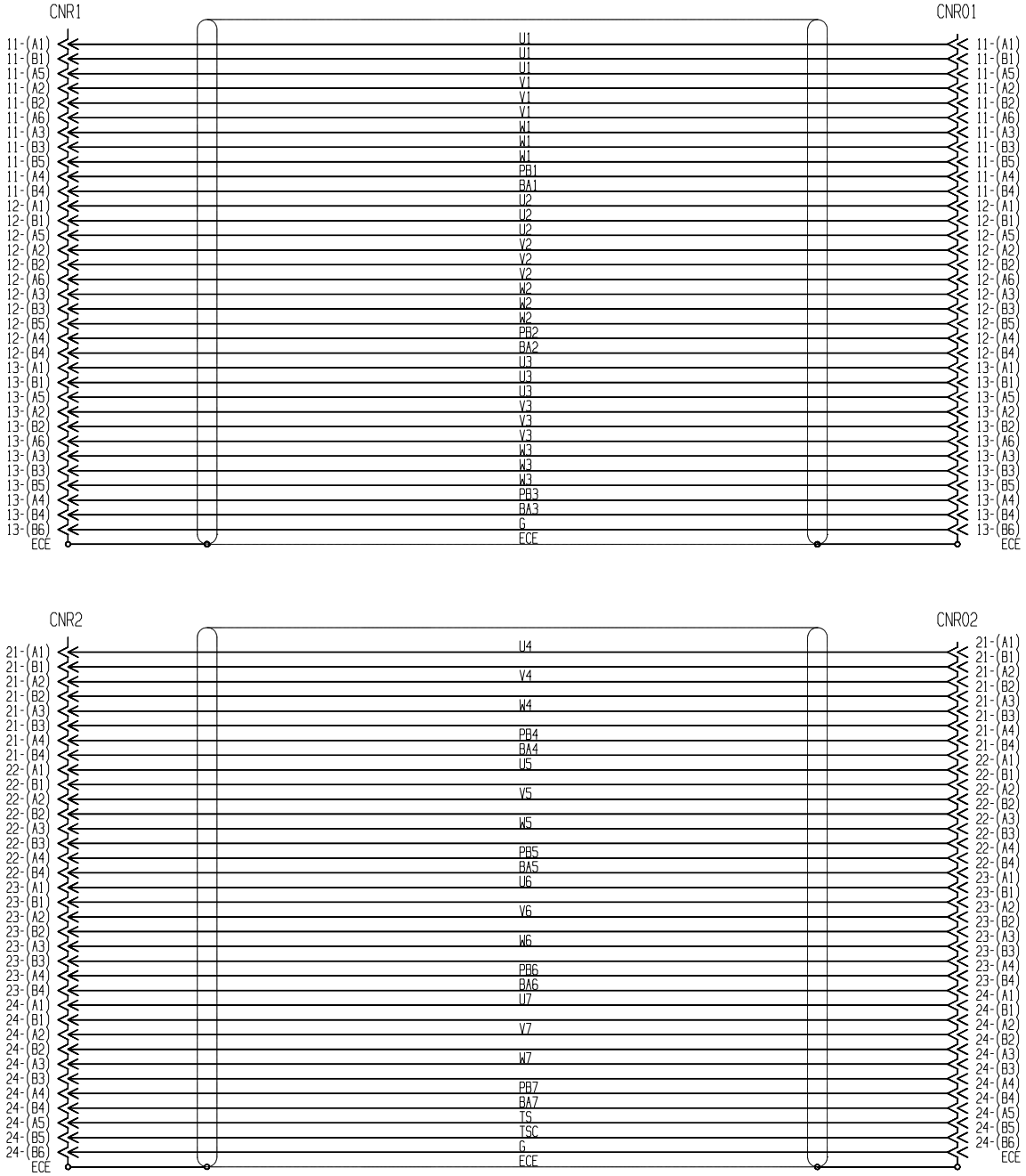


Fig. 7.2-7 Wire harness connection (1)

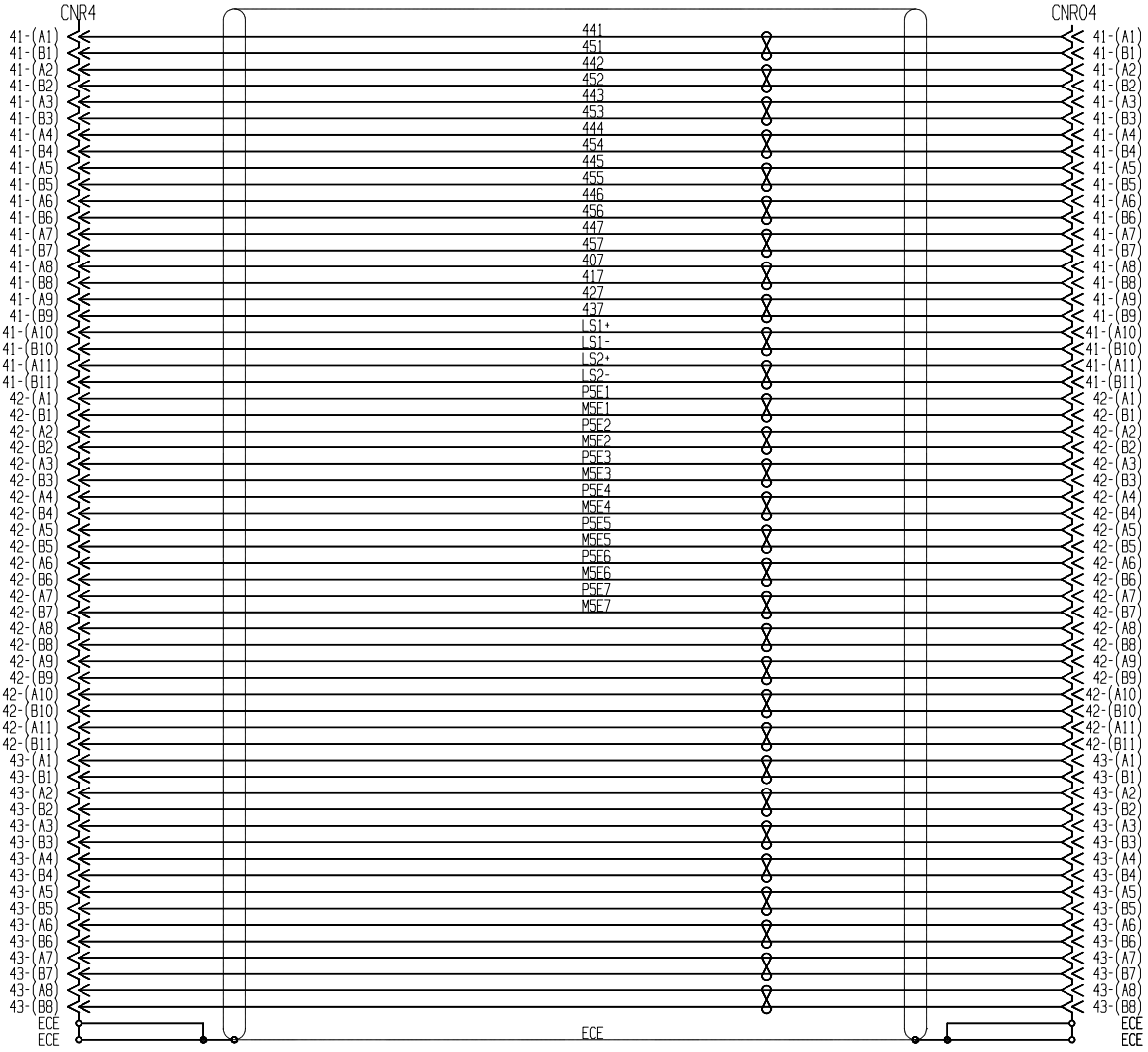


Fig. 7.2-8 Wire harness connection (2)

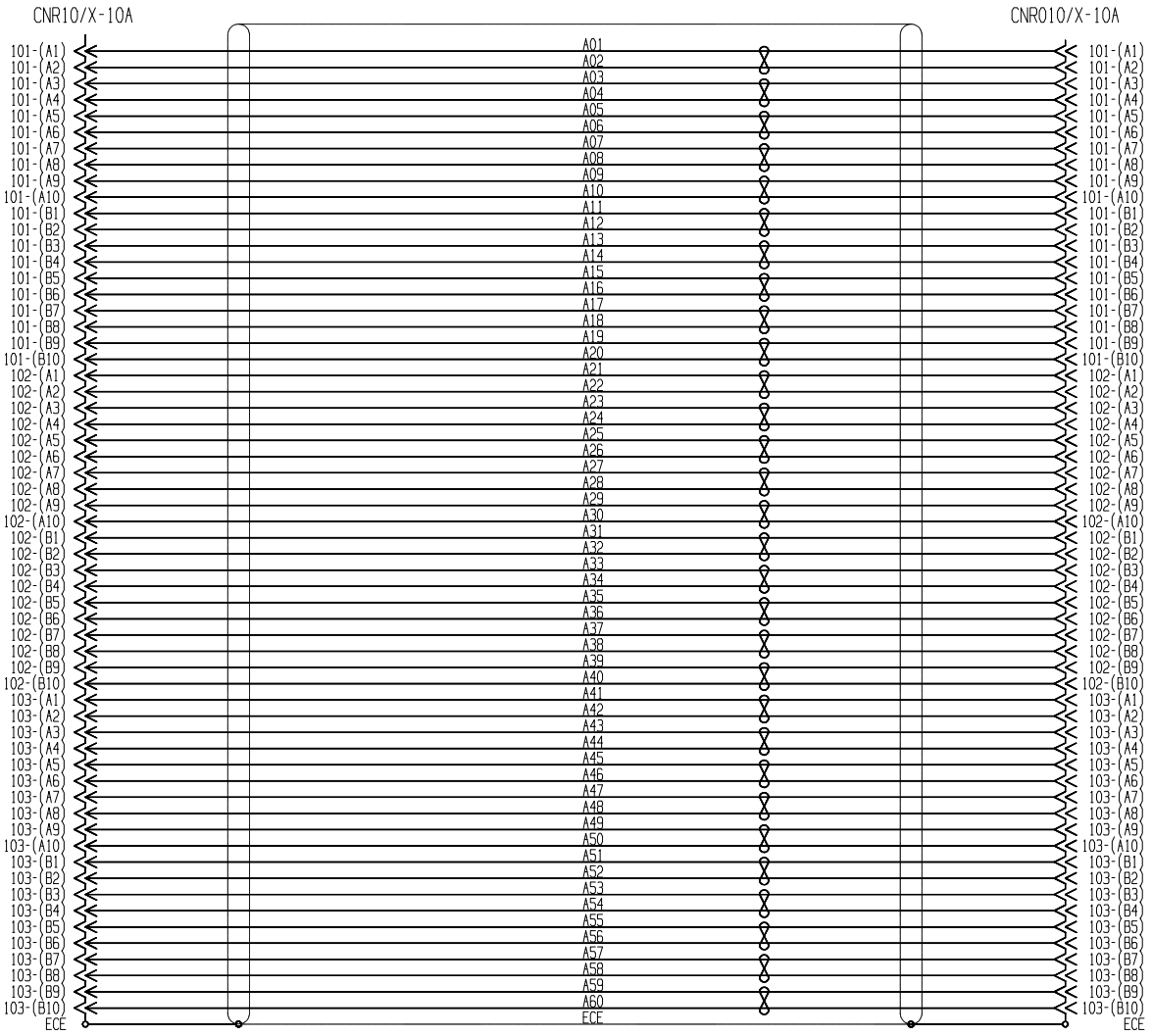


Fig. 7.2-9　Wire harness connection (3)

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