DENSO ROBOT

Vertical articulated

VP-F SERIES

INSTALLATION & MAINTENANCE GUIDE

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Preface

Thank you for purchasing this high-speed, high-accuracy assembly robot.

Before operating your robot, read this manual carefully to safely get the maximum benefit from your robot in your assembling operations.

Robot series and/or models covered by this manual

Series	Model
Mini-sized, vertical articulated VP-F (Models configured with RC7 controller)	VP-6242F (6-axses type) VP-5243F (5-axses type)

NOTE 1: Model names listed above apply to the models of robot systems. The model names of robot units are followed by M. If the robot system model is VP-6242F, for example, the robot unit model is VP-6242FM.

Important

To ensure operator safety, be sure to read the precautions and instructions in "SAFETY PRECAUTIONS".

How the documentation set is organized

The documentation set consists of the following books. If you are unfamiliar with this robot and option(s), please read all books and understand them fully before operating your robot and option(s).

GENERAL INFORMATION ABOUT ROBOT

Provides the packing list of the robot and outlines of the robot system, robot unit, and robot controller.

INSTALLATION & MAINTENANCE GUIDE - this book -

Provides instructions for installing the robot components and customizing your robot, and maintenance & inspection procedures.

BEGINNER'S GUIDE

Introduces you to the DENSO robot. Taking an equipment setup example, this book guides you through running your robot with the teach pendant, making a program in WINCAPSII, and running your robot automatically.

SETTING-UP MANUAL

Describes how to set-up or teach your robot with the teach pendant, operating panel, or mini-pendant.

WINCAPSII GUIDE

Provides instructions on how to use the teaching system WINCAPSII which runs on the PC connected to the robot controller for developing and managing programs.

PROGRAMMER'S MANUAL (I), (II)

Describes the PAC programming language, program development, and command specifications in PAC.

RC7 CONTROLLER INTERFACE MANUAL

Describes the RC7 controller, interfacing with external devices, system- and user-input/output signals, and I/O circuits.

ERROR CODE TABLES

List error codes that will appear on the teach pendant, operating panel, or PC screen if an error occurs in the robot series or WINCAPSII. These tables provide detailed description and recovery ways.

OPTIONS MANUAL

Describes the specifications, installation, and use of optional devices.

How this book is organized

This book is just one part of the robot documentation set. This book consists of SAFETY PRECAUTIONS, chapters one through three.

SAFETY PRECAUTIONS

Defines safety terms and related symbols and provides precautions that should be observed. Be sure to read this section before operating your robot.

Chapter 1 Installing Robot Components

Provides information about physical site planning, installation procedures, and engineering-design notes for hands.

Chapter 2 Customizing Your Robot

Describes how to customize your robot--defining the software motion space and restricted space, CALSETing, and setting control set of motion optimization.

Chapter 3 Maintenance and Inspection

Describes the regular maintenance and inspections necessary for maintaining the performance and functions of your robot.

SAFETY PRECAUTIONS

Be sure to observe all of the following safety precautions.

Strict observance of these warning and caution indications are a MUST for preventing accidents, which could result in bodily injury and substantial property damage. Make sure you fully understand all definitions of these terms and related symbols given below, before you proceed to the text itself.

⚠ **WARNING**	Alerts you to those conditions, which could result in serious bodily injury or death if the instructions are not followed correctly.
⚠ **CAUTION**	Alerts you to those conditions, which could result in minor bodily injury or substantial property damage if the instructions are not followed correctly.

Terminology and Definitions

Maximum space: Refers to the volume of space encompassing the maximum designed movements of all robot parts including the end-effector, workpiece and attachments. (Quoted from the RIA* Committee Draft.)

Restricted space: Refers to the portion of the maximum space to which a robot is restricted by limiting devices (i.e., mechanical stops). The maximum distance that the robot, end-effector, and workpiece can travel after the limiting device is actuated defines the boundaries of the restricted space of the robot. (Quoted from the RIA Committee Draft.)

Motion space: Refers to the portion of the restricted space to which a robot is restricted by software motion limits. The maximum distance that the robot, end-effector, and workpiece can travel after the software motion limits are set defines the boundaries of the motion space of the robot. (The "motion space" is DENSO WAVE-proprietary terminology.)

Operating space: Refers to the portion of the restricted space (or motion space in Denso robot) that is actually used by the robot while performing its task program. (Quoted from the RIA Committee Draft.)

Task program: Refers to a set of instructions for motion and auxiliary functions that define the specific intended task of the robot system. (Quoted from the RIA Committee Draft.)

(*RIA: Robotic Industries Association)

1. Introduction

This section provides safety precautions to be observed during installation, teaching, inspection, adjustment, and maintenance of the robot.

2. Installation Precautions

2.1 Insuring the proper installation environment

2.1.1 For standard type

The standard type has not been designed to withstand explosions, dust-proof, nor is it splash-proof. Therefore, it should not be installed in any environment where:

(1) there are flammable gases or liquids,

(2) there are any shavings from metal processing or other conductive material flying about,

(3) there are any acidic, alkaline or other corrosive gases,

(4) there is cutting or grinding oil mist,

(5) it may likely be submerged in fluid,

(6) there is sulfuric cutting or grinding oil mist, or

(7) there are any large-sized inverters, high output/high frequency transmitters, large contactors, welders, or other sources of electrical noise.

2.1.2 For dust-proof, splash-proof type

The dust-proof, splash-proof type is an IP54-equivalent structure, but it has not been designed to withstand explosions. (The HM/HS-E-W and the wrist of the VM-D-W/VS-E-W are an IP65-equivalent dust-proof and splash-proof structure.)

Note that the robot controller is not a dust- or splash-proof structure. Therefore, when using the robot controller in an environment exposed to mist, put it in an optional protective box.

The dust-proof, splash-proof type should not be installed in any environment where:

(1) there are any flammable gases or liquids,

(2) there are any acidic, alkaline or other corrosive gases,

(3) there are any large-sized inverters, high output/high frequency transmitters, large contactors, welders, or other sources of electrical noise,

(4) it may likely be submerged in fluid,

(5) there are any grinding or machining chips or shavings,

(6) any machining oil not specified in this manual is in use, or

Note: Yushiron Oil No. 4C (non-soluble) is specified.

(7) there is sulfuric cutting or grinding oil mist.

2.2 Service space

The robot and peripheral equipment should be installed so that sufficient service space is maintained for safe teaching, maintenance, and inspection.

2.3 Control devices outside the robot's restricted space

The robot controller, teach pendant, and operating panel should be installed outside the robot's restricted space and in a place where you can observe all of the robot's movements when operating the robot controller, teach pendant, or operating panel.

2.4 Positioning of gauges

Pressure gauges, oil pressure gauges and other gauges should be installed in an easy-to-check location.

2.5 Protection of electrical wiring and hydraulic/pneumatic piping

If there is any possibility of the electrical wiring or hydraulic/pneumatic piping being damaged, protect them with a cover or similar item.

2.6 Positioning of emergency stop switches

Emergency stop switches should be provided in a position where they can be reached easily should it be necessary to stop the robot immediately.

(1) The emergency stop switches should be red.

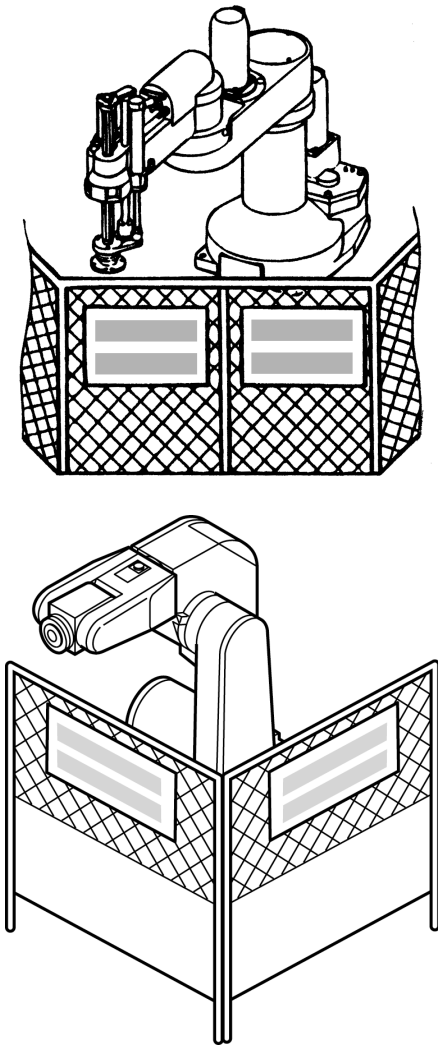
(2) Emergency stop switches should be designed so that they will not be released after pressed, automatically or mistakenly by any other person.

(3) Emergency stop switches should be separate from the power switch.

2.7 Positioning of operating status indicators

Operating status indicators should be positioned in such a way where workers can easily see whether the robot is on temporary halt or on an emergency or abnormal stop.

2.8 Setting-up the safety fence or enclosure



A safety fence or enclosure should be set up so that no one can easily enter the robot's restricted space. If it is impossible, utilize other protectors as described in Section 2.9.

(1) The fence or enclosure should be constructed so that it cannot be easily moved or removed.

(2) The fence or enclosure should be constructed so that it cannot be easily damaged or deformed through external force.

(3) Establish the exit/entrance to the fence or enclosure. Construct the fence or enclosure so that no one can easily get past it by climbing over the fence or enclosure.

(4) The fence or enclosure should be constructed to ensure that it is not possible for hands or any other parts of the body to get through it.

(5) Take any one of the following protections for the entrance/exit of the fence or enclosure:

1) Place a door, rope or chain across the entrance/exit of the fence or enclosure, and fit it with an interlock that ensures the emergency stop device operates automatically if it is opened or removed.

2) Post a warning notice at the entrance/exit of the fence or enclosure stating "In operation--Entry forbidden" or "Work in progress--Do not operate" and ensure that workers follow these instructions at all times.

When making a test run, before setting up the fence or enclosure, place an overseer in a position outside the robot's restricted space and one in which he/she can see all of the robot's movements. The overseer should prevent workers from entering the robot's restricted space and be devoted solely to that task.

2.9 Positioning of rope or chain

If it is not possible to set up the safety fence or enclosure described in Section 2.8, hang a rope or chain around the perimeter of the robot's restricted space to ensure that no one can enter the restricted space.

(1) Ensure the support posts cannot be moved easily.

(2) Ensure that the rope or chain's color or material can easily be discerned from the surrounds.

(3) Post a warning notice in a position where it is easy to see stating "In operation--Entry forbidden" or "Work in progress --Do not operate" and ensure that workers follow these instructions at all times.

(4) Set the exit/entrance, and follow the instructions given in Section 2.8, (3) through (5).

2.10 Setting the robot's motion space

The area required for the robot to work is called the robot's operating space.

If the robot's motion space is greater than the operating space, it is recommended that you set a smaller motion space to prevent the robot from interfering or disrupting other equipment.

Refer to the "INSTALLATION & MAINTENANCE GUIDE."

2.11 No robot modification allowed

Never modify the robot unit, robot controller, teach pendant or other devices.

2.12 Cleaning of tools

If your robot uses welding guns, paint spray nozzles, or other end-effectors requiring cleaning, it is recommended that the cleaning process be carried out automatically.

2.13 Lighting

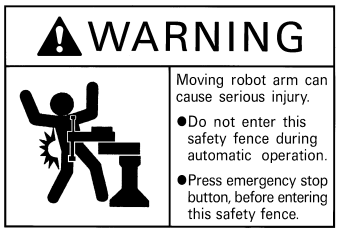
Sufficient illumination should be assured for safe robot operation.

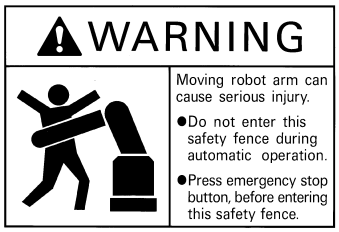
2.14 Protection from objects thrown by the end-effector

If there is any risk of workers being injured in the event that the object being held by the end-effector is dropped or thrown by the end-effector, consider the size, weight, temperature and chemical nature of the object and take appropriate safeguards to ensure safety.

2.15 Affixing the warning label

Place the warning label packaged with the robot on the exit/entrance of the safety fence or in a position where it is easy to see.

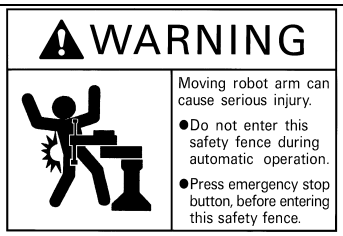


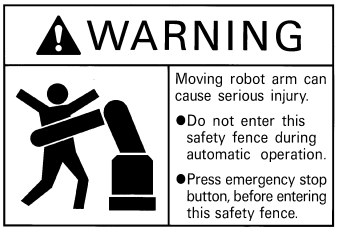


3. Precautions while robot is running

⚠ Warning

Touching the robot while it is in operation can lead to serious injury. Please ensure the following conditions are maintained and that the cautions listed from Section 3.1 onwards are followed when any work is being performed.





1) Do not enter the robot's restricted space when the robot is in operation or when the motor power is on.
2) As a precaution against malfunction, ensure that an emergency stop device is activated to cut the power to the robot motor upon entry into the robot's restricted space.
3) When it is necessary to enter the robot's restricted space to perform teaching or maintenance work while the robot is running, ensure that the steps described in Section 3.3 "Ensuring safety of workers performing jobs within the robot's restricted space" are taken.

3.1 Creation of working regulations and assuring worker adherence

When entering the robot's restricted space to perform teaching or maintenance inspections, set "working regulations" for the following items and ensure workers adhere to them.

(1) Operating procedures required to run the robot.

(2) Robot speed when performing teaching.

(3) Signaling methods to be used when more than one worker is to perform work.

(4) Steps that must be taken by the worker in the event of a malfunction, according to the contents of the malfunction.

(5) The necessary steps for checking release and safety of the malfunction status, in order to restart the robot after robot movement has been stopped due to activation of the emergency stop device

(6) Apart from the above, any steps below necessary to prevent danger from unexpected robot movement or malfunction of the robot.

1) Display of the control panel (See Section 3.2 on the following page)
2) Assuring the safety of workers performing jobs within the robot's restricted space (See Section 3.3 on the following page)

3) Maintaining worker position and stance

   Position and stance that enables the worker to confirm normal robot operation and to take immediate refuge if a malfunction occurs.

4) Implementation of measures for noise prevention

5) Signaling methods for workers of related equipment

6) Types of malfunctions and how to distinguish them

Please ensure "working regulations" are appropriate to the robot type, the place of installation and to the content of the work.

Be sure to consult the opinions of related workers, engineers at the equipment manufacturer and that of a labor safety consultant when creating these "working regulations".

3.2 Display of operation panel

To prevent anyone other than the worker from accessing the start switch or the changeover switch by accident during operation, display something to indicate it is in operation on the operating panel or teach pendant. Take any other steps as appropriate, such as locking the cover.

3.3 Ensuring safety of workers performing jobs within the robot's restricted space

When performing jobs within the robot's restricted space, take any of the following steps to ensure that robot operation can be stopped immediately upon a malfunction.

(1) Ensure an overseer is placed in a position outside the robot's restricted space and one in which he/she can see all robot movements, and that he/she is devoted solely to that task.

   ① An emergency stop device should be activated immediately upon a malfunction.

   ② Do not permit anyone other than the worker engaged for that job to enter the robot's restricted space.

(2) Ensure a worker within the robot's restricted space carries the portable emergency stop switch so he/she can press it (the robot stop button on the teach pendant) immediately if it should be necessary to do so.

3.4 Inspections before commencing work such as teaching

Before starting work such as teaching, inspect the following items, carry out any repairs immediately upon detection of a malfunction and perform any other necessary measures.

(1) Check for any damage to the sheath or cover of the external wiring or to the external devices.

(2) Check that the robot is functioning normally or not (any unusual noise or vibration during operation).

(3) Check the functioning of the emergency stop device.

(4) Check there is no leakage of air or oil from any pipes.

(5) Check there are no obstructive objects in or near the robot's restricted space.

3.5 Release of residual air pressure

Before disassembling or replacing pneumatic parts, first release any residual air pressure in the drive cylinder.

3.6 Precautions for test runs

Whenever possible, have the worker stay outside of the robot's restricted space when performing test runs.

3.7 Precautions for automatic operation

(1) At start-up

Before the robot is to be started up, first check the following items as well as setting the signals to be used and perform signaling practice with all related workers.

1) Check that there is no one inside the robot's restricted space.

2) Check that the teach pendant and tools are in their designated places.

3) Check that no lamps indicating a malfunction on the robot or related equipment are lit.

(2) Check that the display lamp indicating automatic operation is lit during automatic operation.

(3) Steps to be taken when a malfunction occurs

Should a malfunction occur with the robot or related equipment and it is necessary to enter the robot's restricted space to perform emergency maintenance, stop the robot's operation by activating the emergency stop device. Take any necessary steps such as placing a display on the starter switch to indicate work is in progress to prevent anyone from accessing the robot.

3.8 Precautions in repairs

(1) Do not perform repairs outside of the designated range.

(2) Under no circumstances should the interlock mechanism be removed.

(3) When opening the robot controller's cover for battery replacement or any other reasons, always turn the robot controller power off and disconnect the power cable.

(4) Use only spare tools specified in this manual.

4. Daily and periodical inspections

(1) Be sure to perform daily and periodical inspections. Before starting jobs, always check that there is no problem with the robot and related equipment. If any problems are found, take any necessary measures to correct them.

(2) When carrying out periodical inspections or any repairs, maintain records and keep them for at least 3 years.

5. Management of floppy disks

(1) Carefully handle and store the "Initial settings" floppy disks packaged with the robot, which store special data exclusively prepared for your robot.

(2) After finishing teaching or making any changes, always save the programs and data onto floppy disks.

Making back-ups will help you recover if data stored in the robot controller is lost due to the expired life of the back-up battery.

(3) Write the names of each of the floppy disks used for storing task programs to prevent incorrect disks from loading into the robot controller.

(4) Store the floppy disks where they will not be exposed to dust, humidity and magnetic field, which could corrupt the disks or data stored on them.

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Chapter 1 Installing Robot Components

1.1 Preparing a Proper Environment for Installation

Before installing the robot unit and robot controller, confirm that the operating environment is in conformity with each item of "SAFETY PRECAUTIONS, 2. Installation Precautions," and that the surrounding environment of the location where the robot is to be used meets the specifications as described below. Also, take proper measures to protect the components from vibration.

In an inappropriate environment, the robot will not operate to its full capacity or performance, components may not last long, and unexpected failure may result.

1.1.1 Installation Environments

The robot is not explosion-proof, dust-proof or splash-proof, so it should not be installed in any environment where:

(1) there are flammable gases or liquids,

(2) there are any shavings from metal processing or other conductive material flying about,

(3) there are any acidic, alkaline or other corrosive gases,

(4) there is cutting or grinding oil mist,

(5) there is sulfuric cutting or grinding oil mist, or

(6) there are any large-sized inverters, high output/high frequency transmitters, large contactors, welders, or other sources of electrical noise.

1.1.2 Ambient Temperature and Humidity

Keep the ambient temperature between 0°C and 40°C during operation.

Keep the ambient humidity at 90% or below to prevent dew condensation.

1.1.3 Vibration

Do not install the robot in an environment where it will be exposed to excessive vibration or impact.

Caution:	**When the excessive vibration is added to the robot unit at power-off during transportation, ERROR 2AF1 (Encoder reference position error) may occur. If the ERROR 2AF1 occurs when turning the robot controller ON at first after purchasing the robot, refer to the "ERROR CODE TABLES" or contact our Robot Service Section.**

1.1.4 Connecting the Robot Unit and Robot Controller

Before delivery, the robot unit and the robot controller are configured as a set. If you purchase two or more robot systems, take care not to mistake each set when connecting robot units and controllers.

> ⚠**Caution: For the position of the serial number, see "3.2 Outer Dimensions and Operating Range" for the robot unit and "4.2 Outer Dimensions" for the robot controller.**

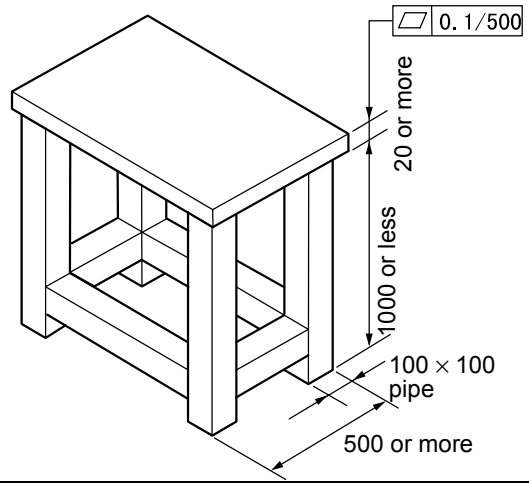
1.1.5 Installation Environment of the Robot Unit

The installation requirements for the robot unit are shown on the next page. Prepare a highly rigid mount by referring to the figure on page 4.

> ⚠**Caution Do not electric-weld the equipment including the robot. A large current may flow through the motor encoder or robot controller resulting in a failure. If electric welding is required, remove the robot unit and the robot controller from the equipment beforehand.**

Installation Requirements for the Robot Unit

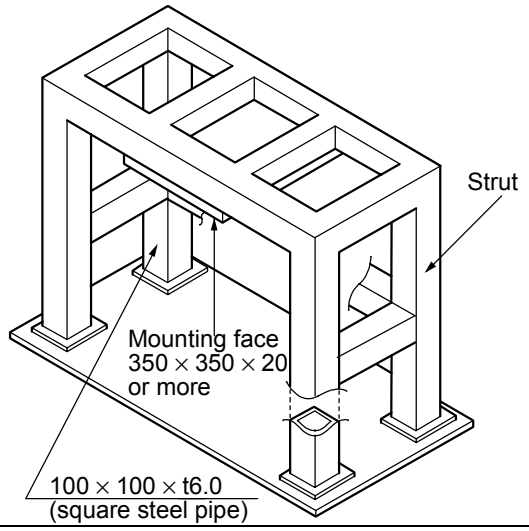
<table>
<tr><th>Item</th><th colspan="2">Environments and Conditions</th></tr>
<tr><td>Flatness of the mount</td><td colspan="2">0.1/500 mm (See the upper figure on the next page.)</td></tr>
<tr><td>Rigidity of the mount</td><td colspan="2">Use steel materials. (See the figure on the next page.)</td></tr>
<tr><td>Installation type</td><td colspan="2">Floor-mount or Overhead mount</td></tr>
<tr><td>Ambient temperature</td><td colspan="2">During operation : 0 to 40°C
During storage and transportation : -10 to 60°C</td></tr>
<tr><td>Humidity</td><td colspan="2">During operation : 90% or less (No dew condensation allowed.)
During storage and transportation : 75% or less (No dew condensation allowed.)</td></tr>
<tr><td>Vibration</td><td colspan="2">During operation : 4.9 m/s^2 (0.5G) or less
During storage and transportation : 29.4 m/s^2 (3G) or less</td></tr>
<tr><td rowspan="2">Safe installation environment</td><td colspan="2">The robot should not be installed in an environment where:
• there are flammable gases or liquids,
• there are any acidic, alkaline or other corrosive gases,
• there is sulfuric cutting or grinding oil mist, or
• there are any large-sized inverters, high output/high frequency transmitters, large contactors, welders, or other sources of electrical noise.</td></tr>
<tr><td>Degree of protection:
IP30</td><td>The robot should not be installed in an environment where:
• there are any shavings from metal processing or other conductive material flying about,
• there is cutting or grinding oil mist, or
• it may be directly exposed to water, oil or cutting chips.</td></tr>
<tr><td>Working space, etc.</td><td colspan="2">• Sufficient service space must be available for inspection and disassembly.
• Keep wiring space (190 mm or more) behind the robot, and fasten the wiring to the mounting face or beam so that the weight of the cables will not be directly applied to the connectors.</td></tr>
<tr><td>Installation conditions</td><td colspan="2">Grounding resistance: 100 Ω or less
See the figure on page 9.</td></tr>
</table>



⚠Caution (1) When the robot operates at high speed, the robot mount undergoes large reaction forces. The mount must be rigid enough so that it will not vibrate or be displaced due to reaction forces. It is also advisable to mechanically join the robot mount with heavy equipment.

(2) Some mounts may produce a resonance sound (howling). If this sound is loud, increase the rigidity of the mount or slightly modify the robot speed.

Robot Mount Example for Floor-mount



⚠Caution (1) When the robot operates at high speed, the top plate structure undergoes large reaction forces. Design the vibration-proof mount so that the top plate will not vibrate due to reaction forces. Also design the top plate structure so that it separates from other top plate structures in the equipment.

(2) Some mounts may produce a resonance sound (howling). If this sound is loud, increase the rigidity of the mount or slightly modify the robot speed.

Robot Mount Example for Overhead-mount

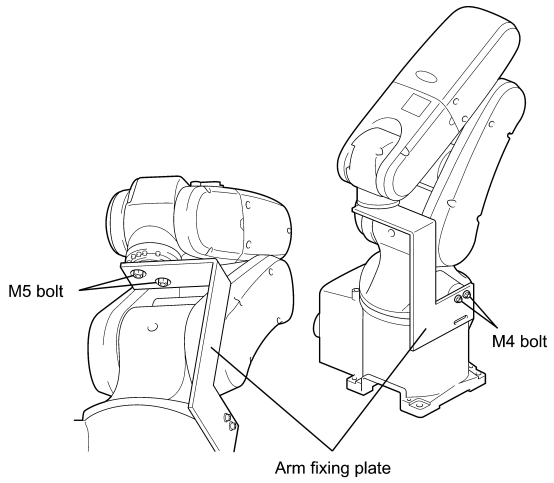
1.2 Installing the Robot Unit

⚠Caution Before handling or installing the robot unit, be sure to read "SAFETY PRECAUTIONS, 2. Installation Precautions."

1.2.1 Transporting the Robot Unit

An arm fixing plate is used to secure the robot arms during transportation from the factory and should be removed after installation.

Caution: The robot unit should only be moved prior to installation if the arm fixing plate is in place. The arm fixing plate should also be affixed if there is the possibility of great impact being applied to the robot unit during transportation. (See the table below for axes angles when affixing the arm fixing plate.) If the robot unit is subjected to significant impacts when the arm fixing plate is not in place, the arm angles may shift slightly and cause Error 6773 to be displayed on the controller. Encoder resetting and CALSET must be performed if this occurs.



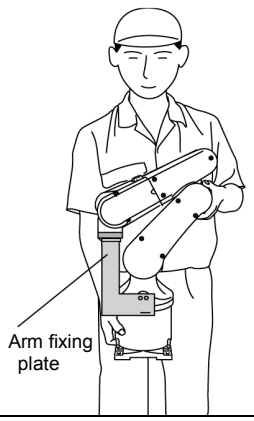
Axis angles when affixing the arm fixing plate (degrees)

Axis	VP-6242F	VP-5243F
J1	-90.0000	-90.0000
J2	-40.0420	-39.9915
J3	158.9266	128.9209
J4	0.0000	-
J5	61.1154	91.0706
J6	0.0000	0.0000

Note: Release the brake for all axes after affixing the arm fixing plate to ensure that stress is not applied to the individual axes.

Robot Unit and Arm Angles When Packaged (When securing the arms with the arm fixing plate)

The VP-F robot unit weighs approximately 14 kg, making it possible for the unit to be moved by one person. Always exercise the necessary level of care and attention when moving the robot unit.



Handling the VP-F Robot Unit

1.2.2 Installing the Robot Unit

(1) Drill four bolt holes (M8) 20-mm deep or more, and two dowel pin holes (ϕ4, H7 for diamond shaped pin, and ϕ6H7 for internally threaded positioning pin) 10-mm deep or more in the robot mounting position where the robot unit is to be secured, according to the dimension in the figure below.

(2) Drive the diamond-shaped pin into the ϕ4H7 hole so that it orients as shown below.

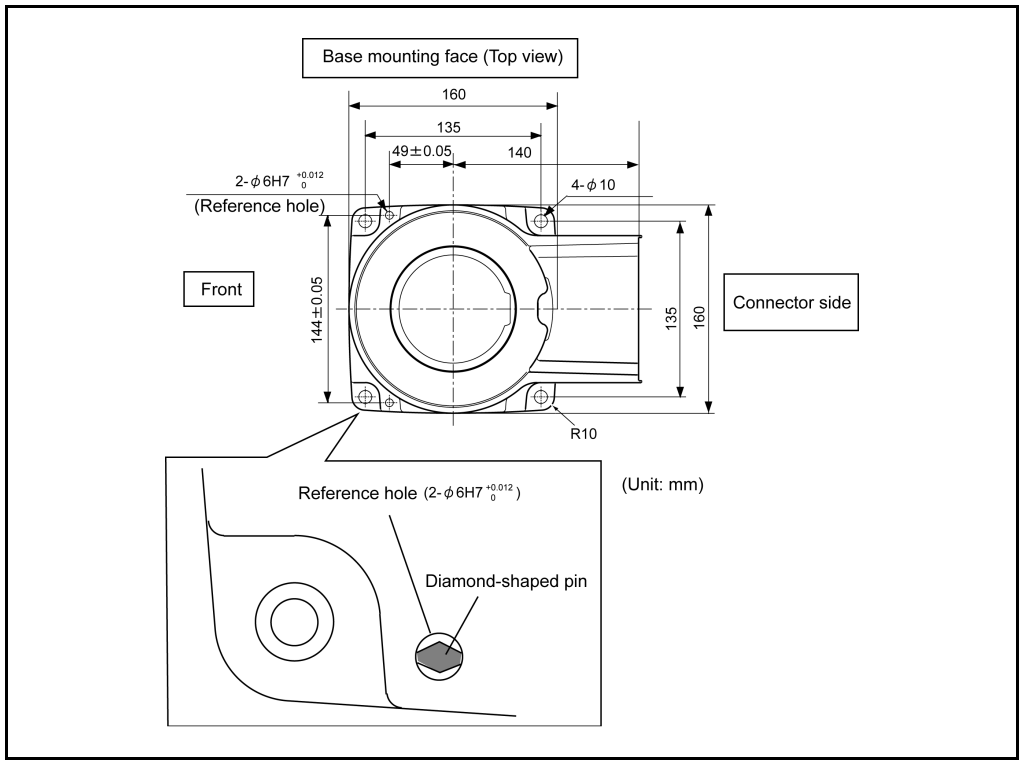
(3) Drive the internally threaded positioning pin into the ϕ6H7 hole.

NOTE: Be sure to drive the knock pins. It can minimize positional deviations that may be caused by the removal/installation of the robot unit for maintenance or the vibration during operation.

(4) Set the robot unit into place on the robot mount.

(5) Secure the robot unit to the mount with four bolts and plain washers.

- Bolt: M8 × 30 mm (strength class: 12.9)
- Tightening torque: 35 ±7 Nm

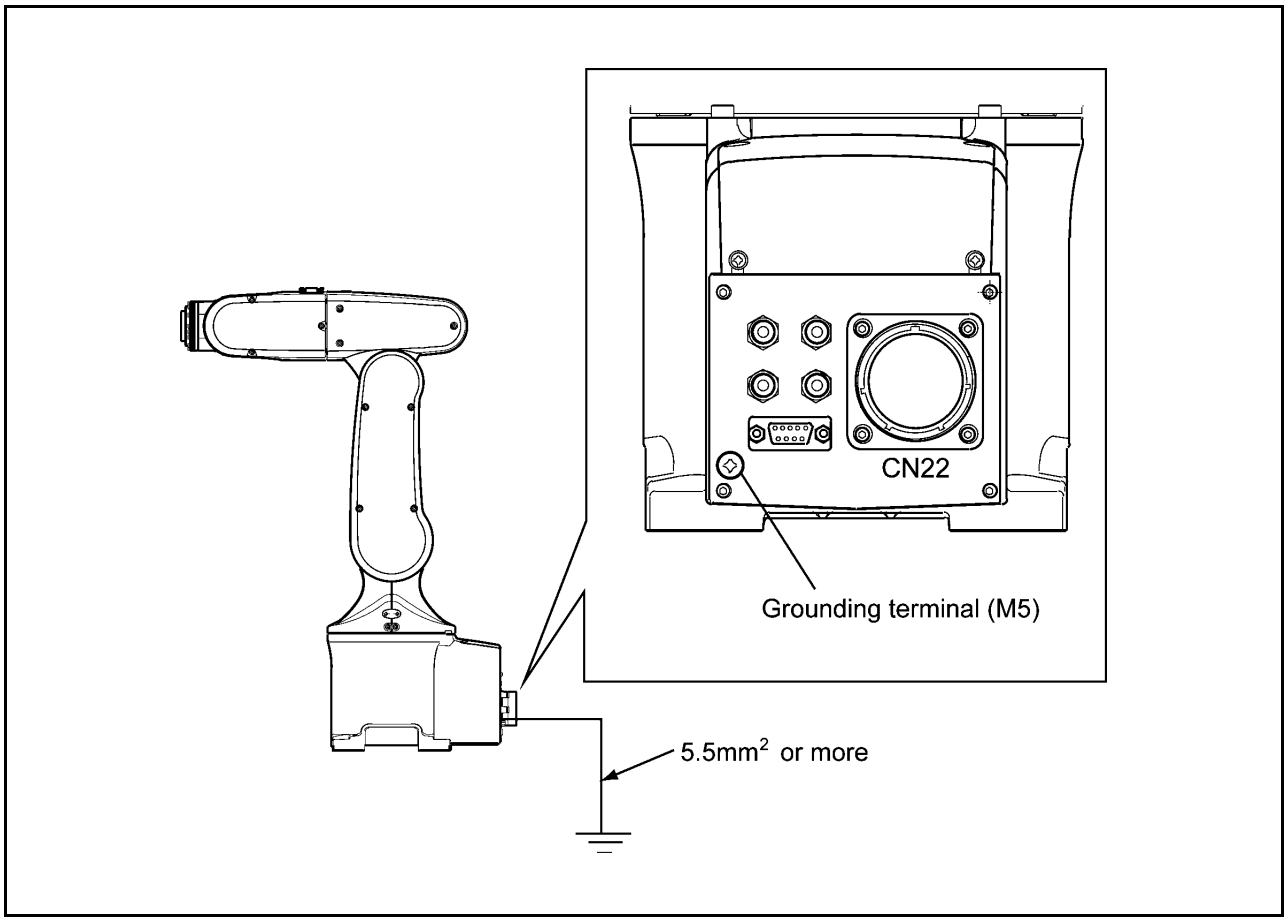


Bolt Positions for Securing the Robot Unit (VP-F series)

1.2.3 Grounding the Robot Unit

Ground the grounding terminal of the robot unit with a wire of 5.5 mm^2 or more.

NOTE: Use a dedicated grounding wire and grounding electrode. Do not share them with any other electric power or power equipment such as a welder.



Grounding the Robot Unit (VP-F series)

1.3 Installing the Robot Controller

For the installing procedures of the robot controller, refer to the " Section 6.2 Installing the Robot Controller, RC7 CONTROLLER INTERFACE MNUAL".

1.4 Cautions for Designing the Robot Hand

Design an end-effector such that it is in compliance with items (1) to (3) described below.

> **⚠CAUTION** **If the end-effector design precautions are not observed, the clamped parts of the robot unit may become loose, rattle or be out of position. In the worst case, the mechanical parts of the robot and robot controller may become damaged.**

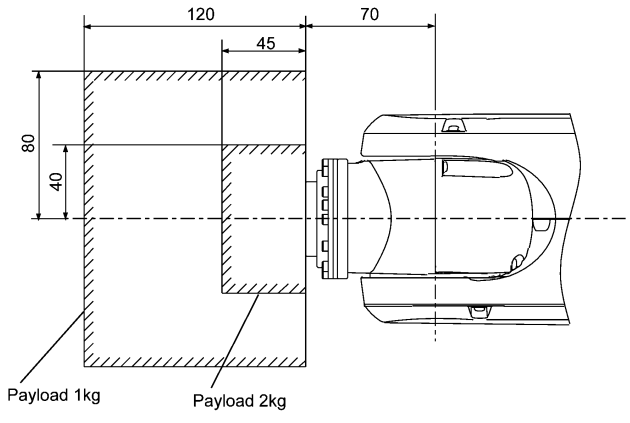
(1) Mass of end-effector

Design the end-effector so that the total mass of the end-effector (including workpiece) will be lighter than the maximum payload capacity of the robot. The total mass includes the wiring, piping, etc.

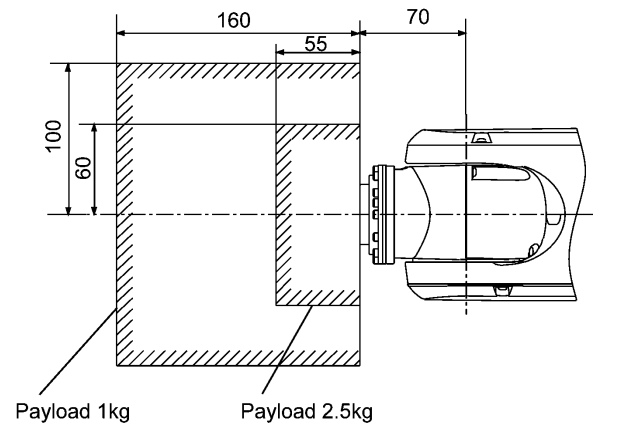
Max. total mass of end-effector (inc. workpiece) ≤ Max. payload capacity

(2) Center of gravity position of end-effector

Design an end-effector so that the center of gravity position of the end-effector (including workpiece) is within the specified range.



VP-6242F



VP-5243F

Allowable Range of Center of Gravity Position of End-effector

(3) Moment of inertia around J4, J5 and J6

Design an end-effector so that its moments of inertia around J4, J5 and J6 (including workpiece) do not exceed the maximum allowable moment of inertia of the robot.

Moment of inertia around J4, J5 and J6 of end-effector (incl. mass of workpiece) ≤ Max. allowable moment of inertia

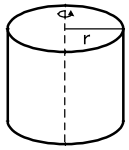
Robot model	Around axis	Maximum allowable moment
VP-6242F	Around J4 or J5	0.030kgm^2
	Around J6	0.007kgm^2
VP-5243F	Around J5	0.040kgm^2
	Around J6	0.010kgm^2

When calculating the moments of inertia around J4, J5 and J6 of the end-effector, use the formulas shown in the table below and the figure on the next page.

Moment-of-Inertia Formulas

1. Cylinder (1)

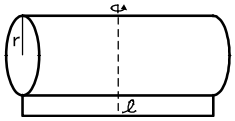
(Axis of rotation = Center axis)



$$I = \frac{mr^2}{2}$$

2. Cylinder (2)

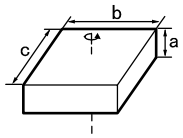
(The axis of rotation passes through the center of gravity.)



$$I = \frac{m}{4}\left(r^2 + \frac{\ell^2}{3}\right)$$

3. Rectangular parallelepiped

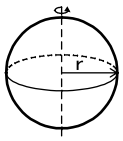
(The axis of rotation passes through the center of gravity.)



$$I = \frac{m}{12}(b^2 + c^2)$$

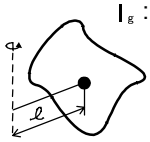
4. Sphere

(Axis of rotation = Center axis)



$$I = \frac{2mr^2}{5}$$

5. Center of gravity not on the axis of rotation



I_g : Inertia moment around center of gravity [kgm^2]

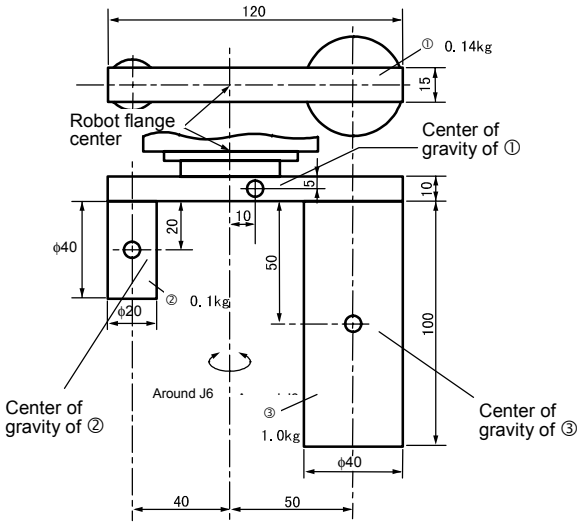
$$I = I_g + m\ell^2$$

I:	Moment of inertia	[kgm^2]
m:	Mass	[kg]
r:	Radius	[m]
b, c, ℓ:	Length	[m]

Calculation example : When calculating the moment of inertia of a complicated shape, divide it into simple parts as much as possible for easier calculations.

As shown in the figure below, divide the end-effector into three parts (①, ②, ③).

(1) Moment of inertia around J6



Unit: mm

Moment of inertia around J6 of ①: I_1 (from 3 and 5 in the table on the preceding page)

$$I_1 = \frac{0.14}{12}(0.12^2 + 0.015^2) + 0.14 \times 0.01^2$$
$$= 1.85 \times 10^{-4} \ [\mathrm{kgm^2}]$$

Moment of inertia around J6 of ②: I_2 (from 1 and 5 in the table on the preceding page)

$$I_2 = \frac{0.1 \times 0.01^2}{2} + 0.1 \times 0.04^2$$
$$= 1.65 \times 10^{-4} \ [\mathrm{kgm^2}]$$

Moment of inertia around J6 of ③: I_3 (from 1 and 5 in the table on the preceding page)

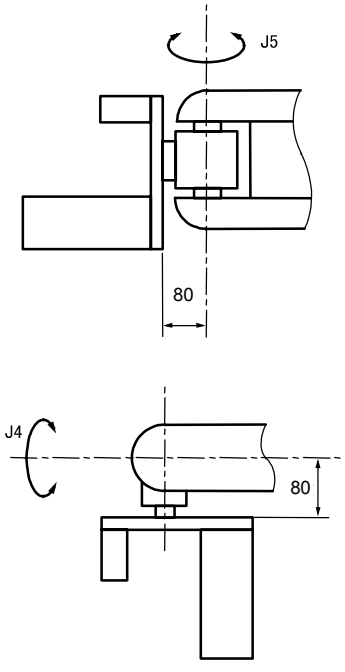
$$I_3 = \frac{1.0 \times 0.02^2}{2} + 1.0 \times 0.05^2$$
$$= 2.7 \times 10^{-3} \ [\mathrm{kgm^2}]$$

Moment of inertia around J6 of entire end-effector: I_{J6}

$$I_{J6} = I_1 + I_2 + I_3 = 0.003 \ [\mathrm{kgm^2}]$$

(2) Moment of inertia around J4 and J5

For the end-effector shown below, the moment of inertia around J4 and J5 can be calculated according to the same formula.



Moment of inertia around J4 and J5 of ①: I_1 (from 3 and 5 in the table on the preceding page)

$$I_1 = \frac{0.14}{12}(0.015^2 + 0.01^2) + 0.14 \times ((0.08 + 0.005)^2 + 0.01)$$
$$= 1.03 \times 10^{-3} \ [\mathrm{kgm^2}]$$

Moment of inertia around J4 and J5 of ②: I_2 (from 2 and 5 in the table on the preceding page)

$$I_2 = \frac{0.1}{4}\left(0.01^2 + \frac{0.04^2}{3}\right) + 0.1 \times ((0.08 + 0.01 + 0.02)^2 + 0.04^2)$$
$$= 1.39 \times 10^{-3} \ [\mathrm{kgm^2}]$$

Moment of inertia around J4 and J5 of ③: I_3 (from 2 and 5 in the table on the preceding page)

$$I_3 = \frac{1.0}{4}\left(0.02^2 + \frac{0.1^2}{3}\right) + 1.0 \times ((0.08 + 0.01 + 0.05)^2 + 0.05^2)$$
$$= 2.30 \times 10^{-3} \ [\mathrm{kgm^2}]$$

Moment of inertia around J4 and J5 of entire end-effector: I_{J4}, I_{J5}

$$I_{J4} = I_{J5} = I_1 + I_2 + I_3 = 2.54 \times 10^{-2} \ [\mathrm{kgm^2}]$$

End-effector Moment of Inertia Calculation Example

Chapter 2 Customizing Your Robot

2.1 What Is Customization?

You may customize your robot by modifying or setting the following:

- Software motion limits for defining motion space
- Mechanical ends for defining restricted space
- Control set of motion optimization
- Robot installation conditions

You are recommended to define new motion space and restricted space in order to prevent interference with other devices or entanglement of the end-effector wiring and piping.

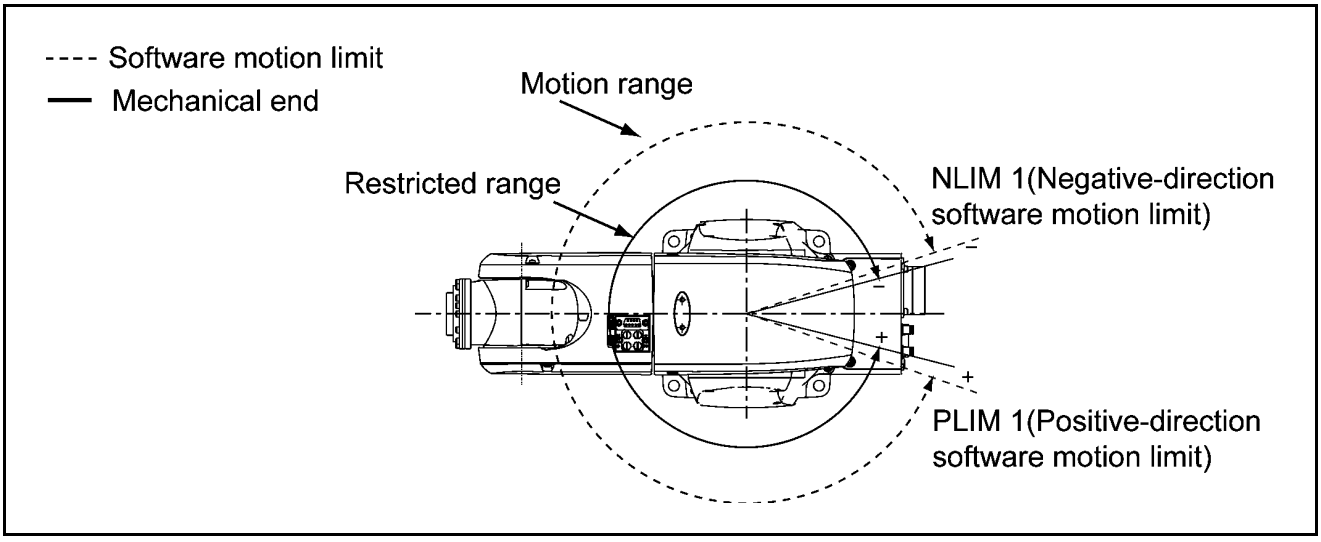
> ⚠**WARNING:**
>
> **Always set the software motion limits and mechanical ends so that the motion space will be within the restricted space. Otherwise, the robot will bump the mechanical stops, causing serious accidents.**

2.2 Modifying Software Motion Limits to Define New Motion Space

2.2.1 What Is a Software Motion Limit?

A limit to the operation range of the robot defined by the software is called a software motion limit. Software motion limits become valid after CAL of the robot has been completed and the robot has entered the range set by the limits.
A mechanical operation limit is called a mechanical end and set by a mechanical stop. To prevent the robot from striking against a mechanical stop, each software motion limit is set slightly in front of the mechanical end as shown in the figure below. Although there is no mechanical stop for the 6th axis, a software motion limit is set.
If the robot reaches a software motion limit during manual or automatic operation, an error message will be displayed (error code starting from 6070; the first digit represents the axis number) and the robot will come to a stop. The power to the motor is also turned OFF in such a case during automatic operation.

All axes are assigned a software motion limit in both the positive and negative direction of the operation range. The software motion limit in the positive direction is called the positive-direction software motion limit and that in the negative direction is called the negative-direction software motion limit.



Software Motion Limits and Mechanical Ends

2.2.2 Factory Defaults of Software Motion Limits

The table below lists the software motion limits that are set at the time of delivery.

Factory Defaults of Software Motion Limits (VP-F series)

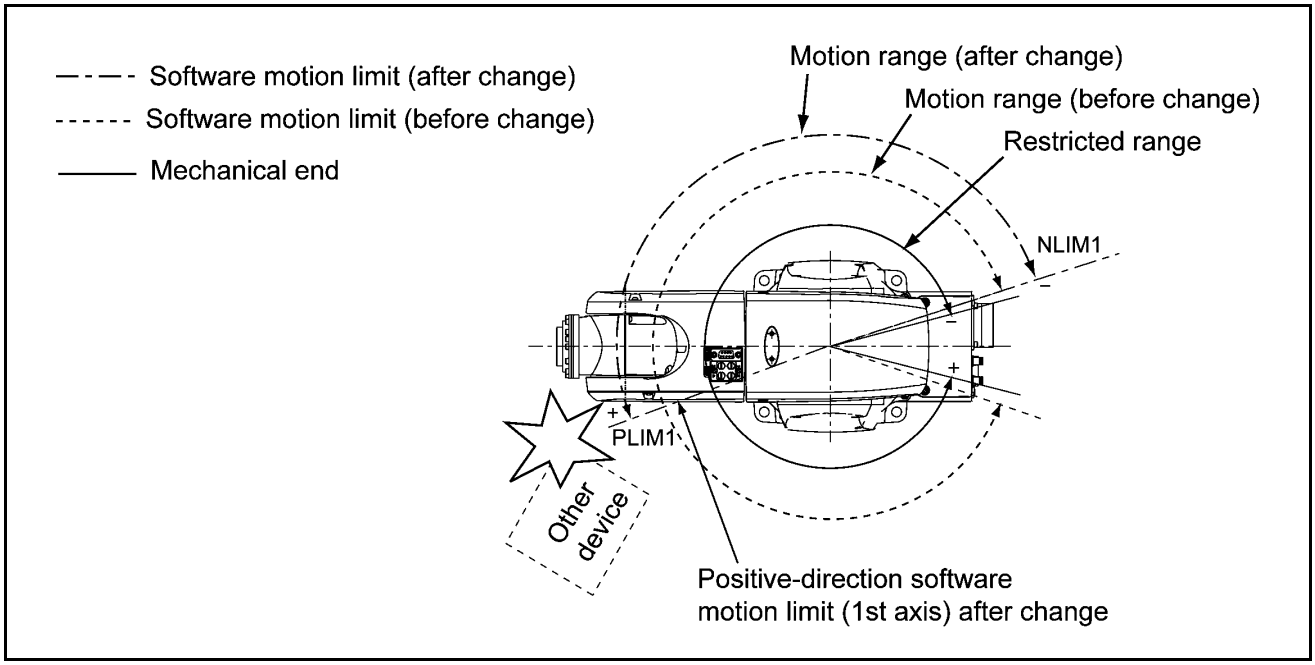
Robot model		1st axis	2nd axis	3rd axis	4th axis	5th axis	6th axis
VP-6242F	Positive direction	160°	120°	160°	160°	120°	360°
	Negative direction	-160°	-120°	19°	-160°	-120°	-360°
VP-5243F	Positive direction	160°	120°	136°		120°	360°
	Negative direction	-160°	-120°	-128°		-120°	-360°

2.2.3 Changing Software Motion Limits

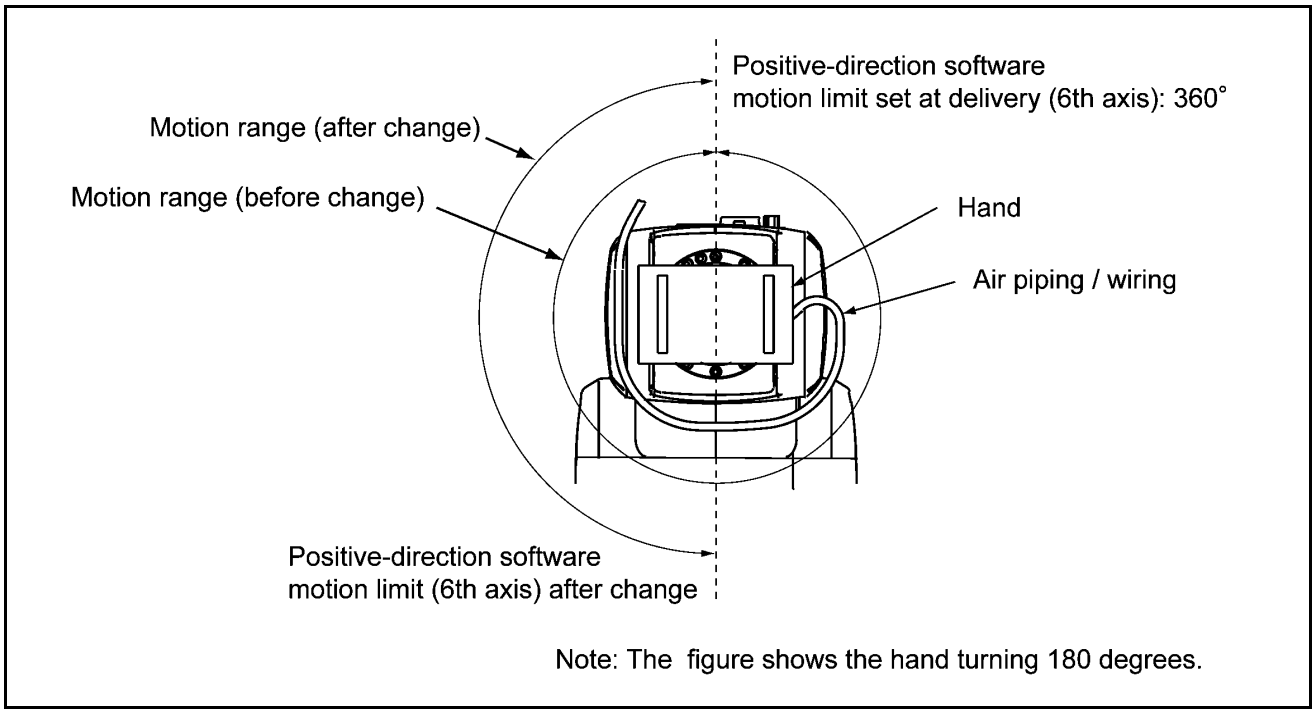
If the robot interferes with any other device, change the software motion limits to make the motion space smaller as shown in the upper figure on this page.

If the air piping or wiring of the end-effector becomes taut as the robot runs, then change the software motion limits to make the motion space smaller as shown in the lower figure on this page.

NOTE: When changing software motion limits, always make the new motion space smaller than the motion space defined by initial settings.



Example 1: Changing Software Motion Limits



Example 2: Changing Software Motion Limits

2.2.4 Precautions When Changing the Software Motion Limits

(1) The software motion limits are invalid until CAL is completed.

(2) Confirm the operating space of the robot in the actual working environment. Set the software motion limits using the correct unit of measurement.

If the operating space is too small, the robot may seem to become inoperable.

2.2.5 Procedure for Changing the Software Motion Limits

Described below is the procedure for changing the software motion limits.

▶ STEP 1

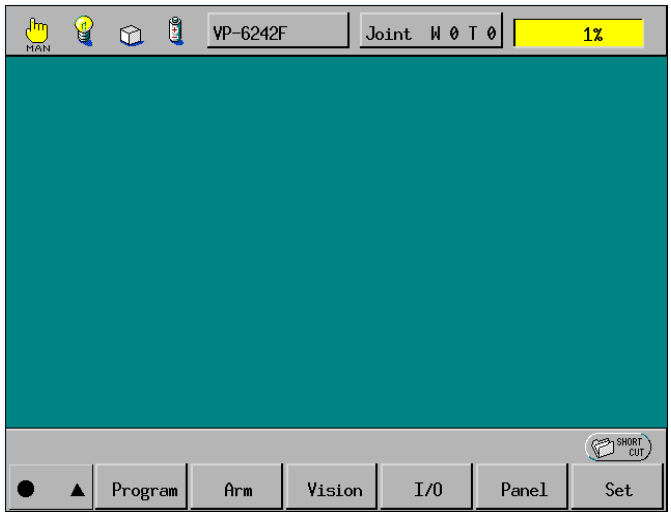
Turn the power switch of the robot controller to ON.

▶ STEP 2

Set the mode selector switch of the teach pendant to MANUAL.

▶ STEP 3

Press [F2 Arm] on the top screen of the teach pendant.

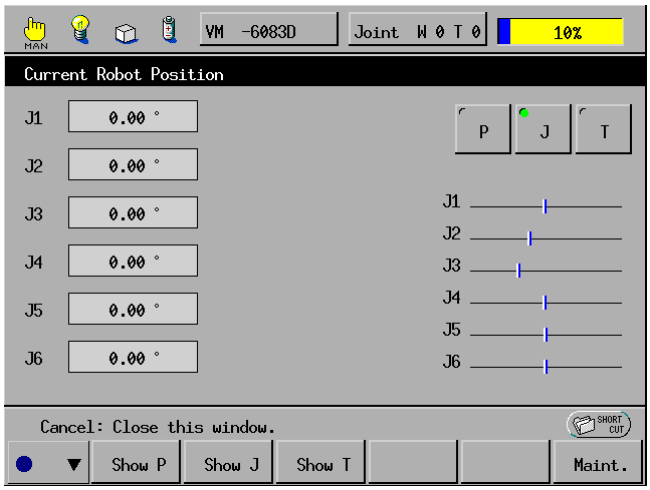


F2

The Current Robot Position window appears as shown in Step 4.

STEP 4

Press the SHIFT key and then press [F12 Maint.].

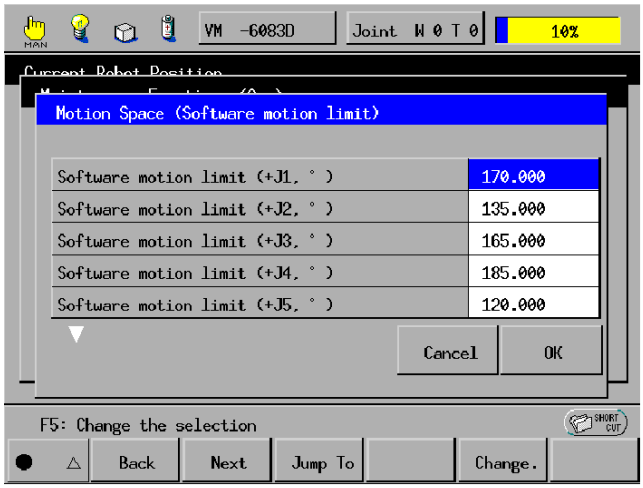


F12

The Maintenance Functions (Arm) window will appear.

STEP 5

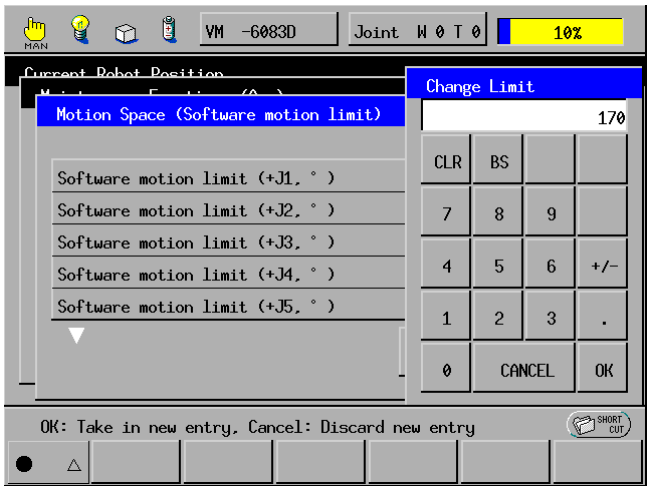
Press [F1 M Space] on the Maintenance Functions (Arm) window.
The Motion Space window will appear as shown below.



F5

STEP 6

Select the item to be modified, then press [F5 Change].
The numeric keypad will appear as shown below.



Enter a desired value using the numeric keys, then press OK.
The new value will be set on the line of the item selected in the Motion Space window.
If two or more items must be changed, repeat Steps 4 and 5.

STEP 7

Press OK in the Motion Space (Software motion limit) window.

STEP 8

Turn OFF the power to the robot controller.

> **Caution: The new software motion limit(s) specified for the motion space will take effect after the robot controller restarts and CAL is completed.**

2.3 Changing the Mechanical End

This section describes the procedures of changing the mechanical ends from the 1st-axis to 3rd-axis.

CAUTIONS AT CHANGING THE MECHANICAL ENDS

1. **When changing the mechanical ends, design the mechanical stoppers according to your usage and manufacture them.**
2. **After changing the mechanical end, the software motion limits (PLIMs, NLIMs) should be changed not to interfere the mechanical end at the robot operation.**
3. **The mechanical stoppers may not limit the workable area of the robot. Therefore, do not enter the robot's restricted space when the robot power is turned ON.**
4. **If the robot is collided with the mechanical stopper, the robot will stop by detecting the collision but the mechanical stopper may be broken.**
   When the robot is collided with the mechanical stopper, remove the mechanical stopper. And inspect the robot and surrounding devices, and repair them. Do not re-use the mechanical stoppers and re-manufacture them.
5. **The reference drawings described on this manual cannot be covered on the customer's usage conditions sufficiently. Design, manufacture and install the mechanical stoppers according to your usage conditions.**
6. **The weight addition by the mechanical stoppers may affect the maximum payload.**
7. **The failures caused by the mechanical stoppers shall not be covered by the warranty even if the robot is under warranty.**

2.3.1 The 1st-axis Mechanical End Change

2.3.1.1 What is the 1st-axis Mechanical End Change?

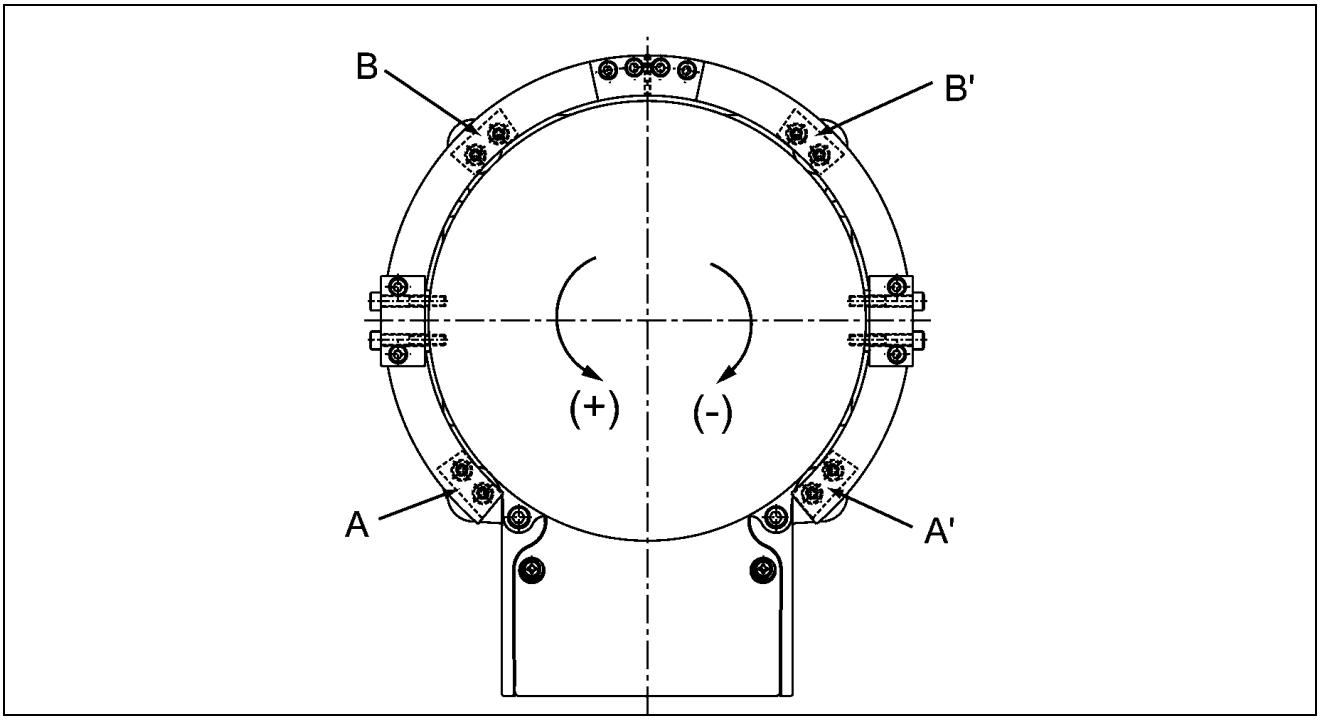
At the time of delivery from the plant, mechanical ends are set in the VP-F series so that the stroke of the 1st axis will be ±170.

Changing the mechanical ends of the 1st axis by adding mechanical stops is called a mechanical end change.

The figure below shows the positions of the mechanical stops at the time of mechanical end change.

The example when the mechanical stopper positions are as specified in the table below.

To change the mechanical ends, four types of mechanical stop parts are required—mechanical stop, fixture blocks A (2 pieces), fixture block B, and plates (2 pieces). Figures on the next pages show the reference drawings of those mechanical stop parts. Referring to those drawings, you should prepare mechanical stop parts as necessary so that your desired motion space may be set.



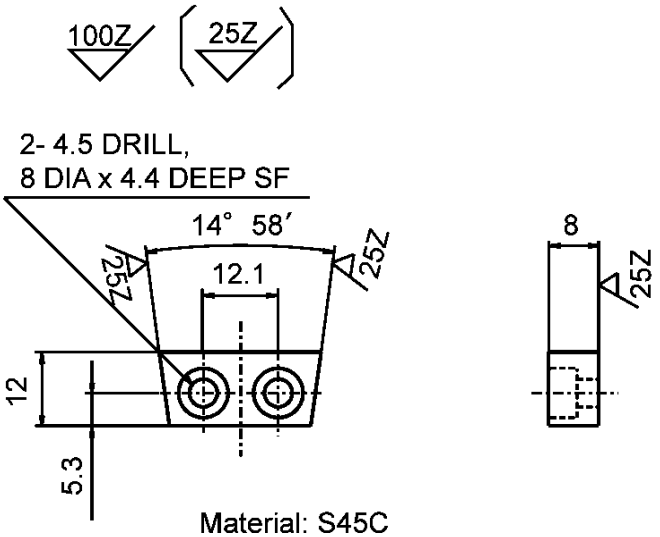
Locations of Mechanical Stops in the VP-F Series

If the 1st axis comes into contact with any mechanical stop because of the width of the stopper and its bolt, the angle of the 1st axis is different between the positive direction and the negative direction. The table below shows --- the angles of the 1st axis in the positive and negative directions when it is in contact with each mechanical stop.

Stroke of the 1st Axis to Mechanical Ends

Mechanical stop position	Positive direction	Negative direction
A’	4°	-
A’	-	-4°
B’	94°	-
B’	-	-94°

VP-F series (For 1st-axis)

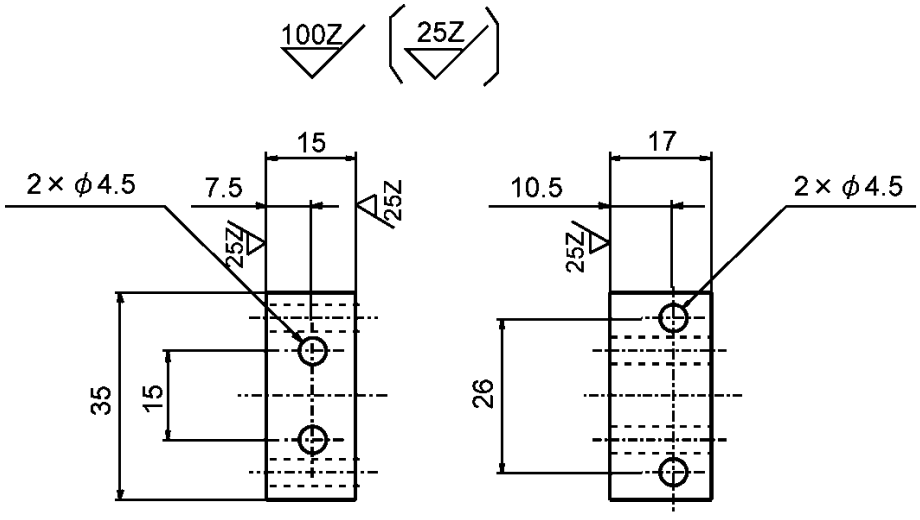


Material: S45C
Unit: mm

Note 1: Unless otherwise specified, corners should be C 0.1 to C 0.5.

Mechanical Stop

VP-F series (For 1st-axis)

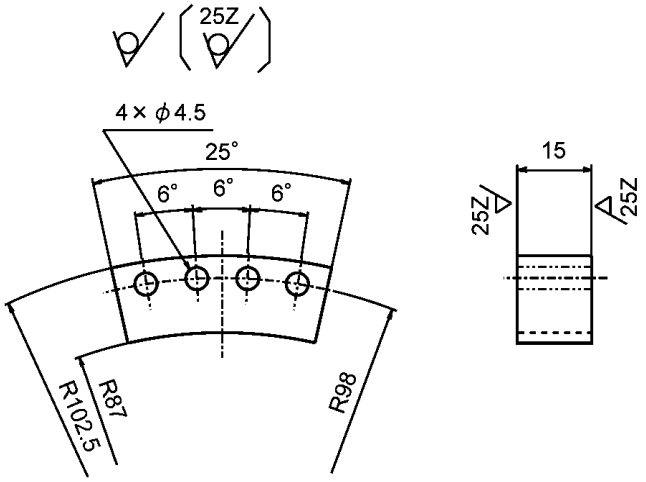


Material: A2017
Unit: mm

Note 1: Unless otherwise specified, corners should be C 0.1 to C 0.5.

Fixture Block A

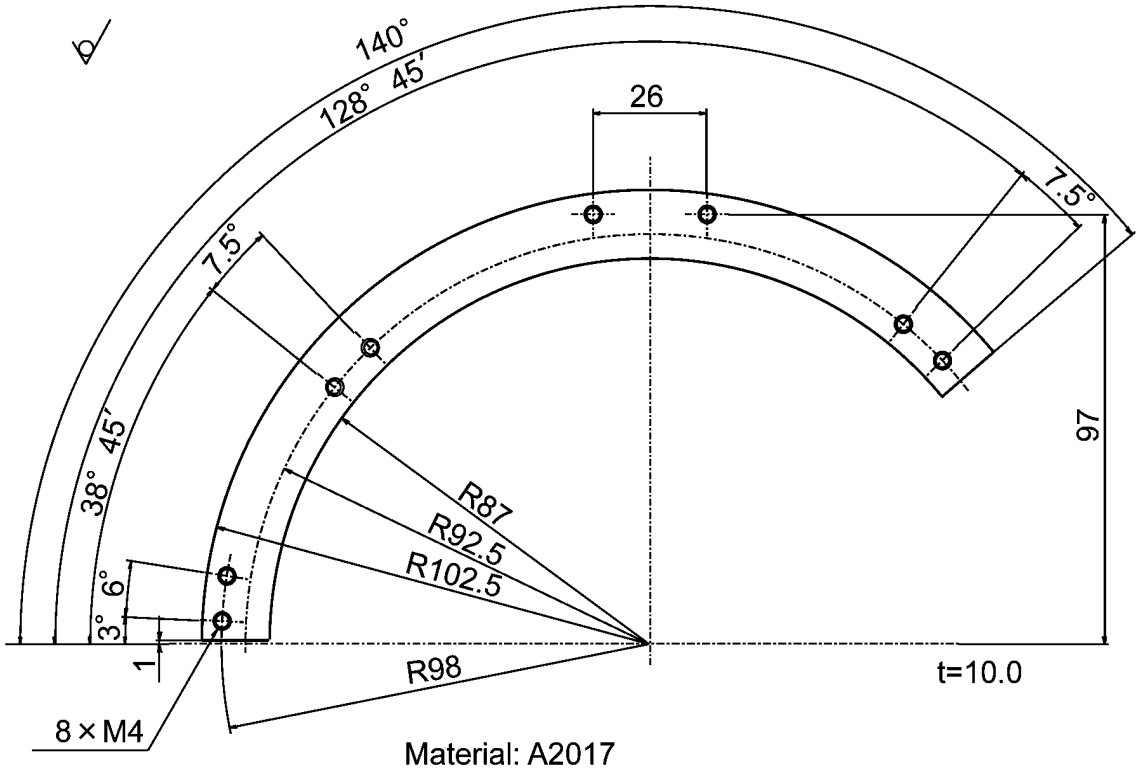
VP-F series (For 1st-axis)



Material: A2017
Unit: mm
Note 1: Unless otherwise specified, corners should be C 0.1 to C 0.5.

Fixture Block B

VP-F series (For 1st-axis)



Material: A2017
Unit: mm
Note 1: Unless otherwise specified, corners should be C 0.1 to C 0.5.

Plate

Precautions When Changing the Mechanical Ends

After a mechanical end change, the software motion limits (PLIMs, NLIMs) must be changed.

And also, if you change the RANG values after a mechanical end change, the CALSET must also be performed.

Note: A RANG is the angle that determines the relationship between the reference position of the robot and the mechanical ends, and is also called a reference angle or ready angle.

(1) If the following case, the RANG values change and the CALSET are not necessary after a mechanical end change.

If you can perform the CALSET after removing the mechanical stop parts prepared by you from the robot when the CALSET becomes necessary (Example: Exchanging the motor).

(2) If the following case, the RANG values change and the CALSET are necessary after a mechanical end change.

If you perform the CALSET for the robot with the mechanical stop parts prepared by you when the CALSET becomes necessary (Example: Exchanging the motor).

In this case, the position repeatability is depended on the mechanical stop parts prepared by you.
And also you need to note down the new RANG values and CALSET values.
The initial RANG values and CALSET values at the time of delivery from the plant are saved in the initialization floppy disk.

In this example, after a mechanical end change, the RANG values must be changed, and CALSET must also be performed.

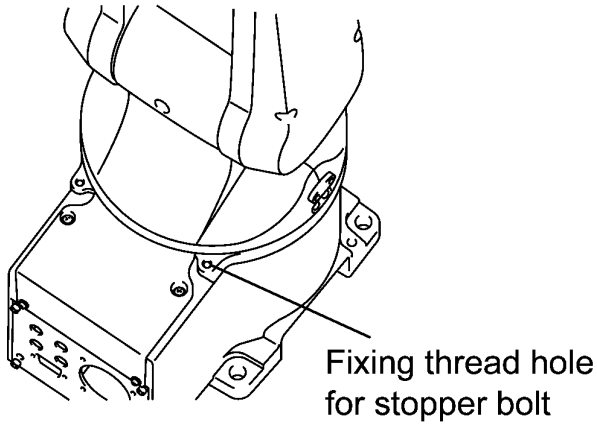
2.3.1.2 Changing the Mechanical Ends

The mechanical ends can be changed by mounting four types of mechanical stop parts (i.e., mechanical stop, fixture blocks A, fixture blocks B, and plates) and then changing the set software motion limits and the RANG values. The procedures for doing this are described in the following sections.

(1) Mounting mechanical stop parts

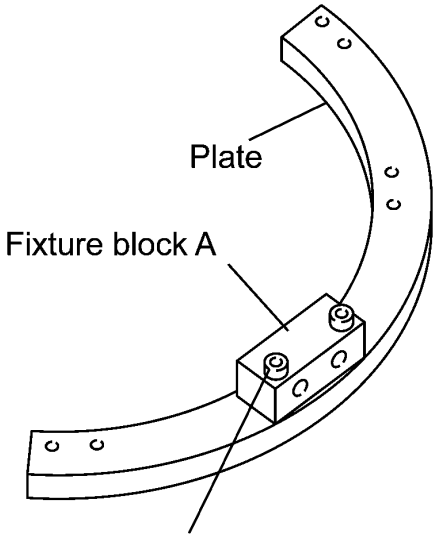
▸ STEP 1

Move the 1st axis of the robot until the stopper bolt comes into the inside of the motion space that you want to set.



STEP 2

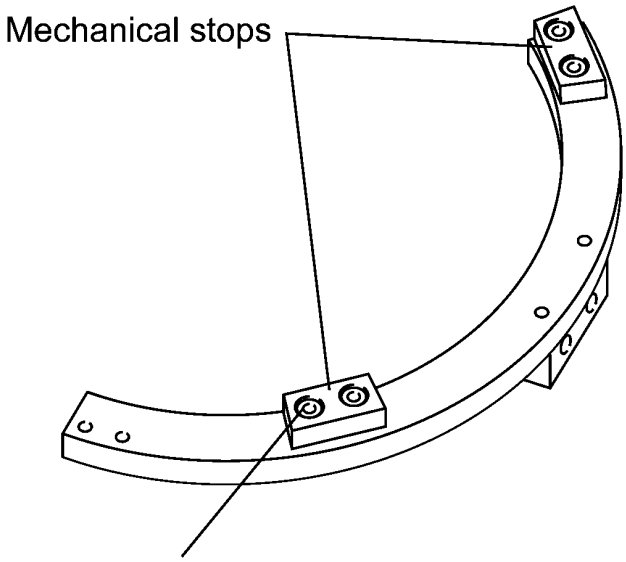
Secure fixture block A to the plate with two hexagonal socket-head bolts. (Make a pair of assemblies.)



Hex. socket-head bolt M4x25 (Strength class: 12.9)
Tightening torque: 3±0.6 Nm

STEP 3

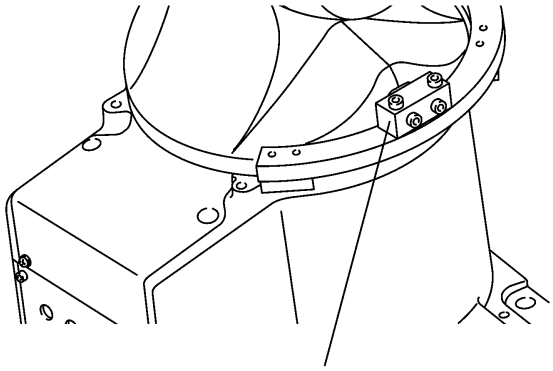
Turn each of the assemblies made in Step 2 upside down. Secure two mechanical stops to it with two hexagonal socket-head bolts each for determining the desired motion space.



Hex. socket-head bolt M4x12 (Strength class: 12.9)
Tightening torque: 3±0.6 Nm

STEP 4

Temporarily secure one of the assemblies made in Step 3 to the side of the 1st axis with hexagonal socket-head bolts.

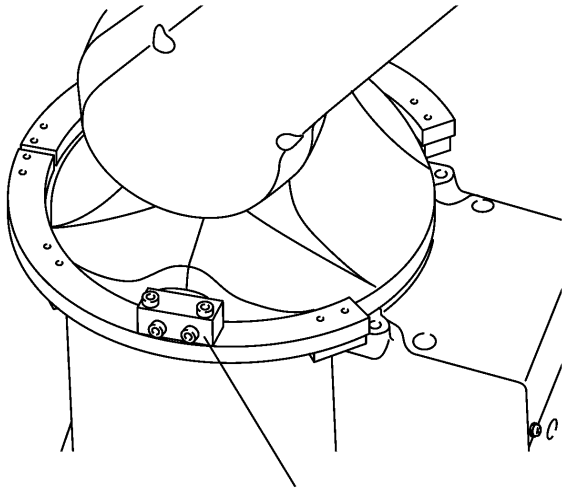


Temporarily tighten bolts.

Hex. socket-head bolt M4x25 (Strength class: 12.9)

STEP 5

In the same way as in Step 4, temporarily secure the other assembly made in Step 4 to the other side of the 1st axis.



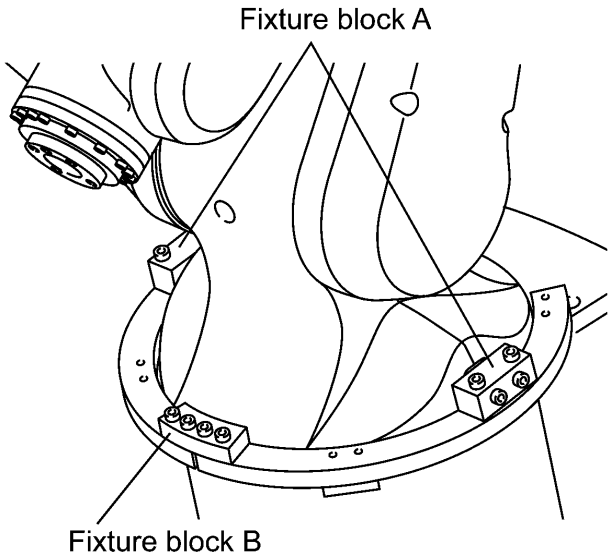
Temporarily tighten bolts.

Hex. socket-head bolt M4x25 (Strength class: 12.9)

STEP 6

Link the assemblies together that you have temporarily secured in Steps 4 and 5, using fixture block B and hexagonal socket-head bolts.

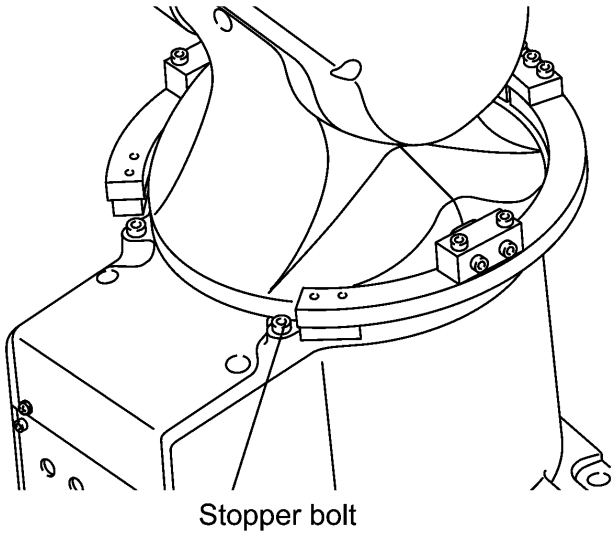
Then firmly tighten the hexagonal socket-head bolts tightened temporarily in Steps 4 and 5.



Hex. socket-head bolt M4x25 (Strength class: 12.9)
Tightening torque: 3±0.6 Nm

STEP 7

Fix the stopper bolt on the robot unit.



Hex. socket-head bolt M5x10 (Strength class: 12.9)
Tightening torque: 6±1.2 Nm

(2) Software motion limits and Set RANG values

Note:	If the following case, the RANG values change and the CALSET are necessary after a mechanical end change. **If you perform the CALSET for the robot with the mechanical stop parts prepared by you when the CALSET becomes necessary (Example: Exchanging the motor).** In this case, the position repeatability is depended on the mechanical stop parts prepared by you. And also you need to note down the new RANG values and CALSET values. The initial RANG values and CALSET values at the time of delivery from the plant are saved in the initialization floppy disk.

The set software motion limits and RANG values must be changed whenever the mechanical end positions are changed. A RANG is the angle that determines the relationship between the reference position of the robot and the mechanical ends, and is also called a reference angle or ready angle. The RANG value checking procedure is given below.

The relationship between each mechanical end position and software motion limits is shown in the table on the next page.

Change the set software motion limits (PLIMs) and RANG values according to the procedures given in "(3) Changing positive-direction software motion limits (PLIMs) and RANG values" and "(4) Changing the negative-direction software motion limits (NLIMs)".

Checking the set RANG values

After mounting the mechanical stop parts, check the RANG values according to the procedure below.

The RANG values that you check here should be entered in the procedure of "(3) Changing positive-direction software motion limits (PLIMs) and RANG values" and "(4) Changing the negative-direction software motion limits (NLIMs)."

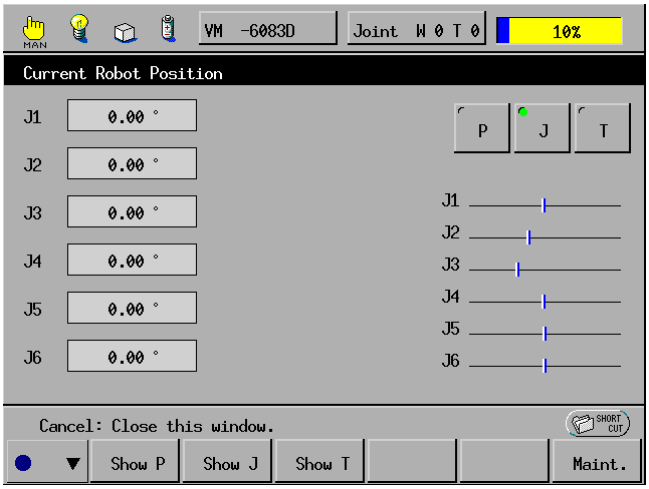
When you use the permanent mechanical end, this checking job is not required.

▶ STEP 1 **Turn the power switch of the robot controller to ON.**

▶ STEP 2 **Set the mode selector switch of the teach pendant to MANUAL.**

STEP 3

Press [F2 Arm] on the top screen.
The Current Robot Position window appears.

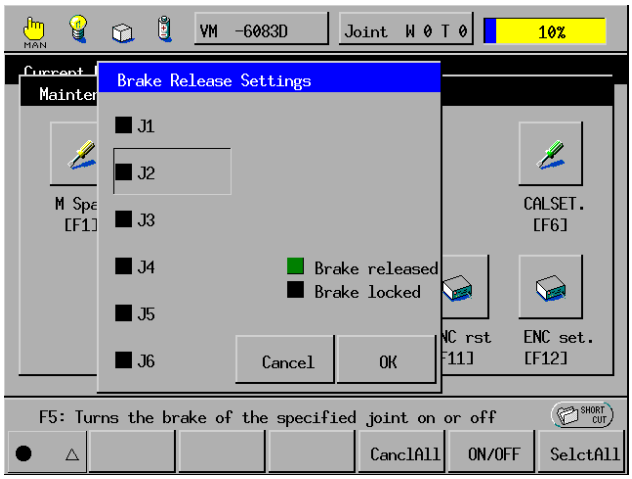


STEP 4

Press [F12 Maint.].
The Maintenance Functions (Arm) window appears.

STEP 5

Press [F3 Brake].
The Brake Release Setting window appears.



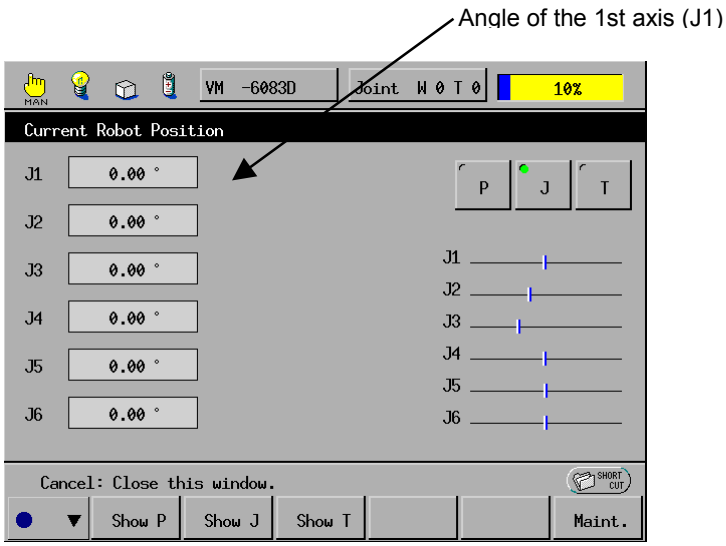
Release the 1st axis (J1) brake.

STEP 6

Gently bring the 1st axis of the robot into contact with the newly set positive-direction mechanical end.

STEP 7

Check the value in J1 box that appears when the 1st axis is in contact with the mechanical end in Step 6. The value is RANG value to be newly set.



Mechanical End Positions and Set Software Motion Limits

	Positive-direction mechanical end				Negative-direction mechanical end			
	A	**B**	**A'**	**B'**	**A**	**B**	**A'**	**B'**
Positive-direction software motion limit	0	90	-	-				
Negative-direction software motion limit					-	-	0	-90

Caution: If you set mechanical ends (in addition to the permanent mechanical end), set the software motion limits 4° inside from the mechanical ends (RANG value). If the software motion limits are set merely less than 4° inside from the mechanical ends, the robot may bump against the mechanical stops before it stops by software.

Examples (1) When the positive-direction mechanical ends are A and the negative-direction ones are the permanent mechanical ends, change:

Positive-direction software motion limit = 0
RANG = value obtained in "Checking the set RANG value"

(2) When the positive-direction mechanical ends are the permanent mechanical ends and the negative-direction mechanical ones are B', change:

Positive-direction software motion limit = -90

(3) When the positive-direction mechanical ends are B and the negative-direction mechanical ends are A', change:

Positive-direction software motion limit = 90
RANG = value obtained in "Checking the set RANG value"
Negative-direction software motion limit = 0

▸ STEP 8

Gently bring the 1st axis of the robot to the original position.
Press the robot stop button, and the brake of the robot is locked.

▸ STEP 9

Release the robot stop button by turning it.

(3) Changing positive-direction software motion limits (PLIMs) and RANG values

The set positive-direction software motion limits (PLIMs) and RANG values must be changed whenever the positive-direction mechanical ends are changed.

Note:	If the following case, the RANG values change and the CALSET are necessary after a mechanical end change. **If you perform the CALSET for the robot with the mechanical stop parts prepared by you when the CALSET becomes necessary (Example: Exchanging the motor).** In this case, the position repeatability is depended on the mechanical stop parts prepared by you. And also you need to note down the new RANG values and CALSET values. The initial RANG values and CALSET values at the time of delivery from the plant are saved in the initialization floppy disk.

Change the set positive-direction software motion limits (PLIMs) and RANG values according to steps 1 through 24 described below.

Changing Positive-Direction Software Motion Limits (PLIMs)

▸ STEP 1

Turn the power switch of the robot controller to ON.

▸ STEP 2

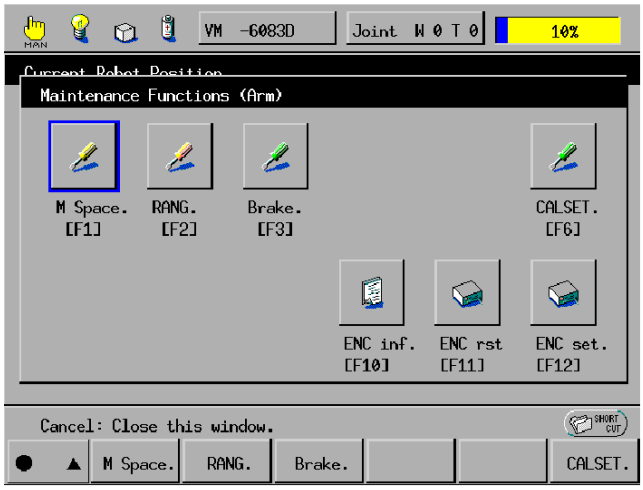
Set the mode selector switch of the teach pendant to MANUAL.

▸ STEP 3

Press [F2 Arm] on the top screen.
The Current Robot Position window appears.

STEP 4

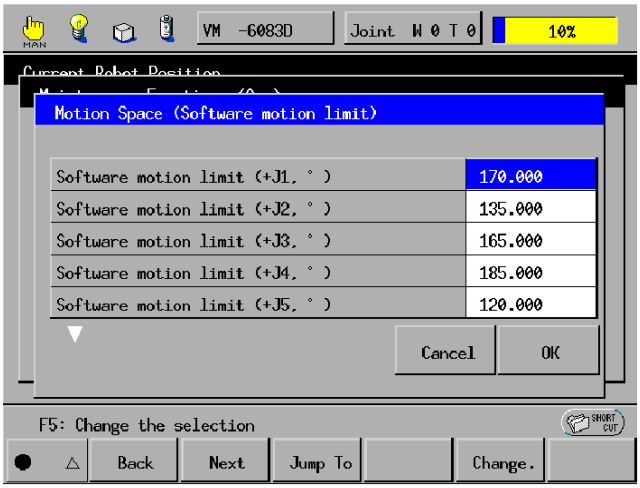
Press [F12 Aux.].
The Maintenance Functions (Arm) window appears.



F1

STEP 5

Press [F1 M Space.].
The Motion Space (Software motion limit) window appears as shown below.



STEP 6

Using the jog dial or cursor keys, select the Software motion limit (+J1, deg) field.

STEP 7

Press [F5 Change.].
The numeric keypad appears.

STEP 8

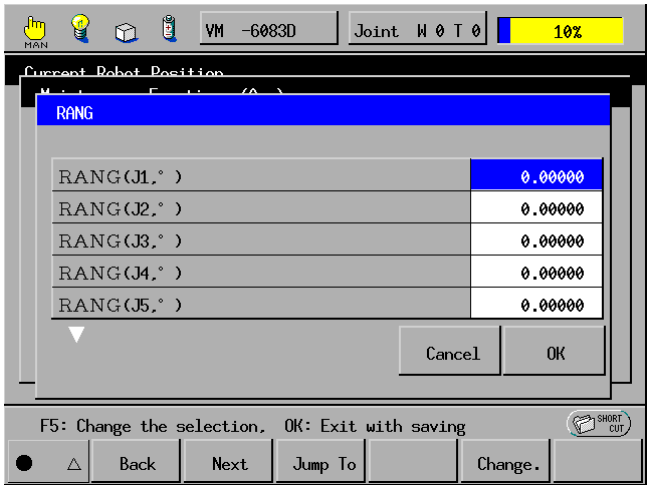
Using the numeric keys, enter the positive-direction software motion limit value, then press OK.
The screen returns to the Motion Space (Software motion limit) window.

STEP 9

Press OK.
The screen returns to the Maintenance Functions (Arm) window.

STEP 10

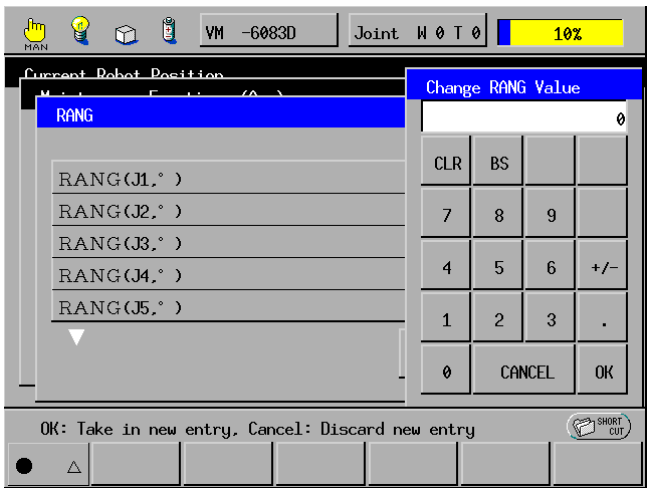
Press [F2 RANG.].
The RANG window appears as shown below.



F5

STEP 11

Press [F5 Change.].
The numeric keypad appears.



STEP 12

Using the numeric keys, enter RANG values, then press OK.
The screen returns to the RANG window.

STEP 13

Press OK.
The screen returns to the Maintenance Functions (Arm) window.

STEP 14

Turn the power switch of the robot controller to OFF.

STEP 15

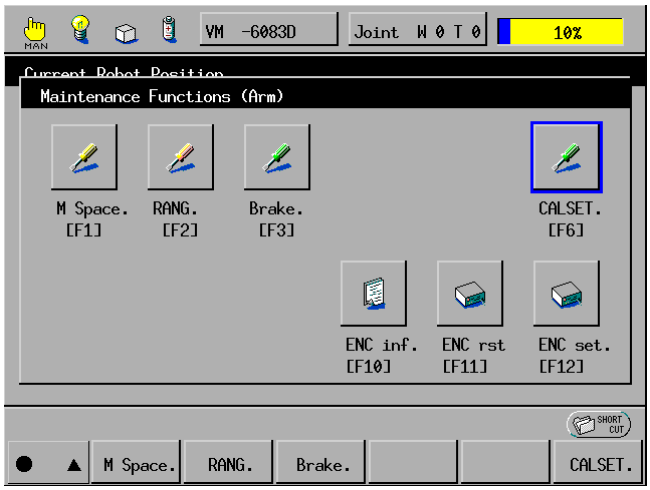
Turn the power switch of the robot controller to ON.

STEP 16

Press [F2 Arm] on the top screen.

STEP 17

Press [F12 Maint.]
The Maintenance Functions (Arm) window appears.



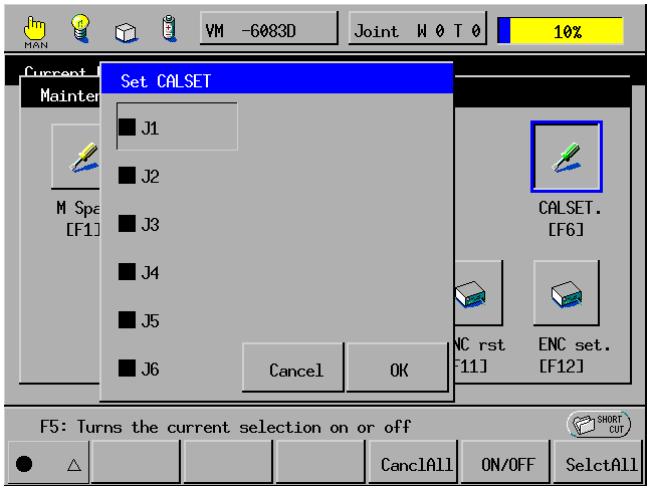
F6

STEP 18

Bring the 1st axis into contact with the positive-direction mechanical end by hand.

STEP 19

Press [F6 CALSET.] .
The Set CALSET window appears.



STEP 20

Touch the J1 field and confirm that the mark turns green.

STEP 21

Press OK.
The message window appears asking you whether you want to execute CALSET.

STEP 22

Press OK.
The message window appears informing you that CALSET is completed.

STEP 23

Press OK.

Caution: After CALSET is completed, move the 1st axis over the full stroke in the manual mode (speed = 10% or less) to confirm that the positive-direction and negative-direction software motion limits function properly. If they are valid, the axis stops just before the mechanical end, and ERROR6071 appears.

In the following cases, reset the bolt positions, the positive-direction software motion limits, the RANG values and the negative-direction software motion limits to the original settings, and repeat the procedure from the beginning:

1) The software motion limits do not function when the axis is near a mechanical end, and another error (6111, 6121 or 6171) occurs.

2) A software motion limit error (ERROR6071) occurs although the axis is not near a mechanical end.

(4) Changing set negative-direction software motion limits (NLIMs)

The set negative-direction software motion limits (NLIMs) must be changed whenever the negative-direction mechanical ends are changed. Change the set negative-direction software motion limits (PLIMs) according to steps 1 through 10 described below.

STEP 1

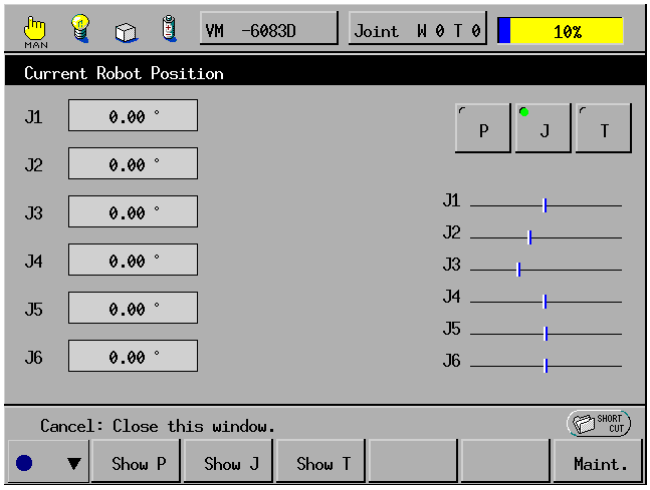
Turn the power switch of the robot controller to ON.

STEP 2

Set the mode selector switch of the teach pendant to MANUAL.

STEP 3

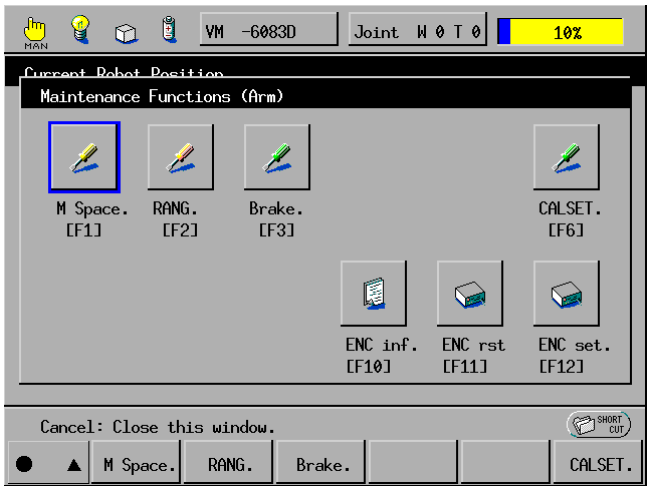
Press [F2 Arm] on the top screen.
The Current Robot Position window appears.



F12

STEP 4

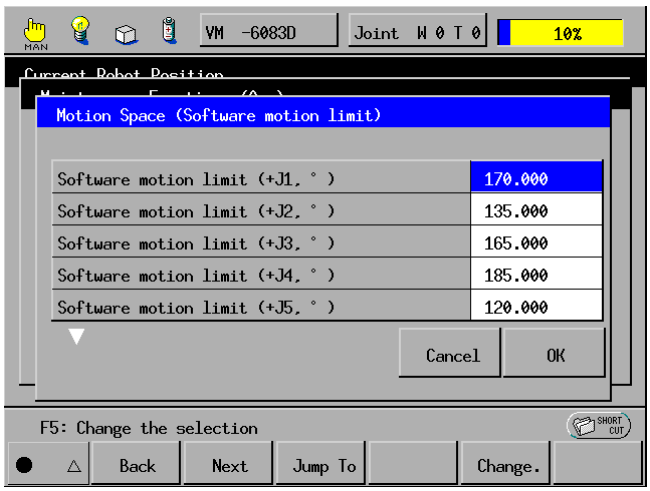
Press [F12 Maint.].
The Maintenance Functions (Arm) window appears.



F1

STEP 5

Press [F1 M Space.].
The Motion Space (Software motion limit) window appears.



STEP 6

Using the jog dial or cursor keys, select the Software motion limit (-J1, deg) field.

STEP 7

Press [F5 Change.].
The numeric keypad appears.

STEP 8

Using the numeric keys, enter a negative-direction software motion limit value, then press OK.
The screen returns to the Motion Space (Software motion limit) window.

STEP 9

Press OK.

STEP 10

Turn the power switch of the robot controller to OFF.

Caution: After changing the software motion limit(s), move the 1st axis over the full stroke in the manual mode (speed = 10% or less) to confirm that the positive- and negative-direction software motion limits function properly. If they are valid, the axis stops just before the mechanical end, and ERROR6071 appears.

In the following cases, reset the bolt positions, the positive-direction software motion limits, the RANG values and the negative-direction software motion limits to the original settings, and repeat the procedure from the beginning:

1) The software motion limits do not function when the axis is near a mechanical end, and another error (6111, 6121 or 6171) occurs.

2) A software motion limit error (ERROR6071) occurs although the axis is not near a mechanical end.

2.3.2 The 2nd-axis Mechanical End Change

To change the mechanical end for the 2nd -axis, you need to prepare the mechanical stop shown in the figure below.

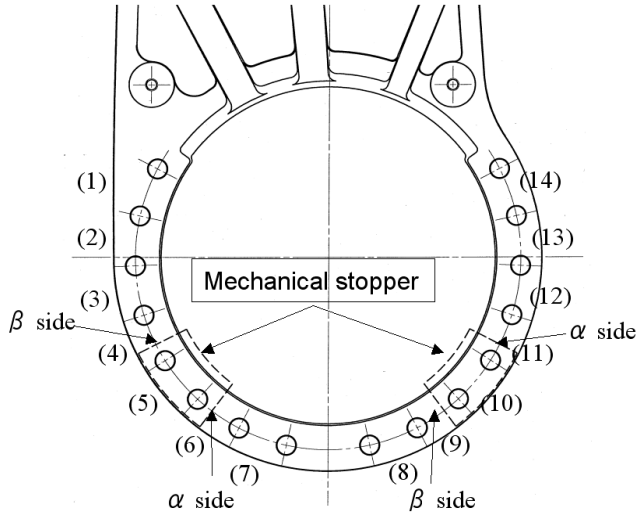
(1) Example of changing the 2nd-axis mechanical end

The figure below show the mechanical stopper positions when changing the mechanical ends, and their software motion limits (PLIM, NLIM).

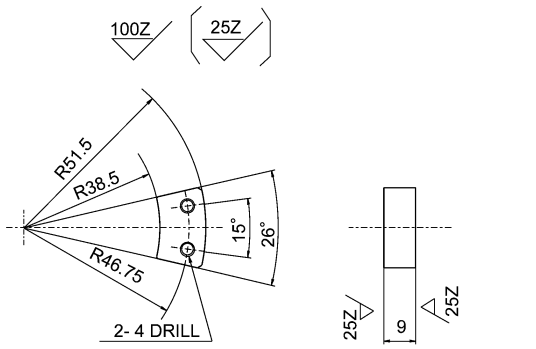
The figure below shows the examples when mechanical stopper position (5) and (10) are used.

When using two mechanical stoppers, set the motion range (PLIM, NLIM) within the common range. For example, when using the mechanical stopper (5) and (10), set the software motion range to "–32 degree to +32 degree".

Example of changing the 2nd-axis mechanical ends



Reference drawing for the 2nd-axis mechanical stopper



Material: S45C
Unit: mm
Note 1: Unless otherwise specified, corners should be C 0.1 to C 0.5.

Software motion limits when changing the 2nd-axis mechanical ends

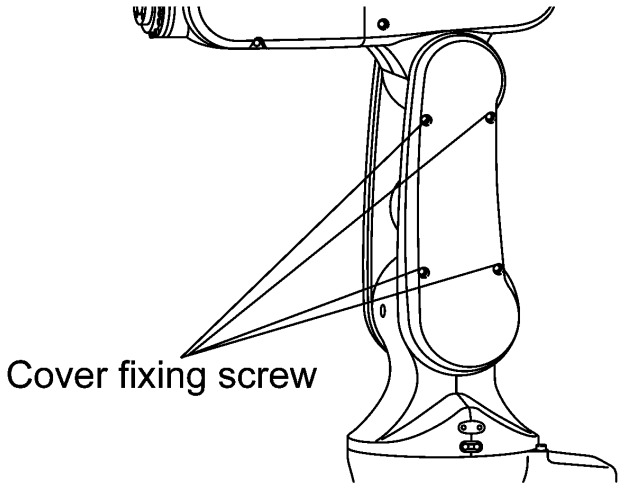
Mechanical stopper position	Touch at α side: Motion range (degrees)	Touch at β side: Motion range (degrees)
Mechanical stopper (1)	92 to −120	−
Mechanical stopper (2)	77 to −120	120 to 113
Mechanical stopper (3)	62 to −120	120 to 98
Mechanical stopper (4)	47 to −120	120 to 83
Mechanical stopper (5)	32 to −120	120 to 68
Mechanical stopper (6)	17 to −120	120 to 53
Mechanical stopper (7)	2 to −120	120 to 38
Mechanical stopper (8)	−38 to −120	120 to −2
Mechanical stopper (9)	−53 to −120	120 to −17
Mechanical stopper (10)	−68 to −120	120 to −32
Mechanical stopper (11)	−83 to −120	120 to −47
Mechanical stopper (12)	−98 to −120	120 to −62
Mechanical stopper (13)	−113 to −120	120 to −77
Mechanical stopper (14)	−	120 to −92

The 2nd-axis Mechanical End Change (Examples)

(2) Procedures of changing the 2nd-axis mechanical ends

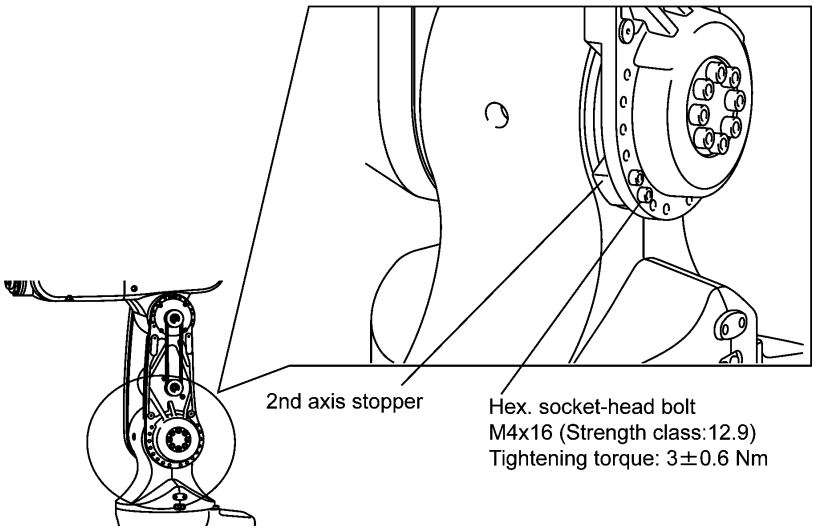
STEP 1

Unscrew four cover-fixing screws and remove the cover.



STEP 2

The figure below shows the example of "Mechanical stopper (5)".



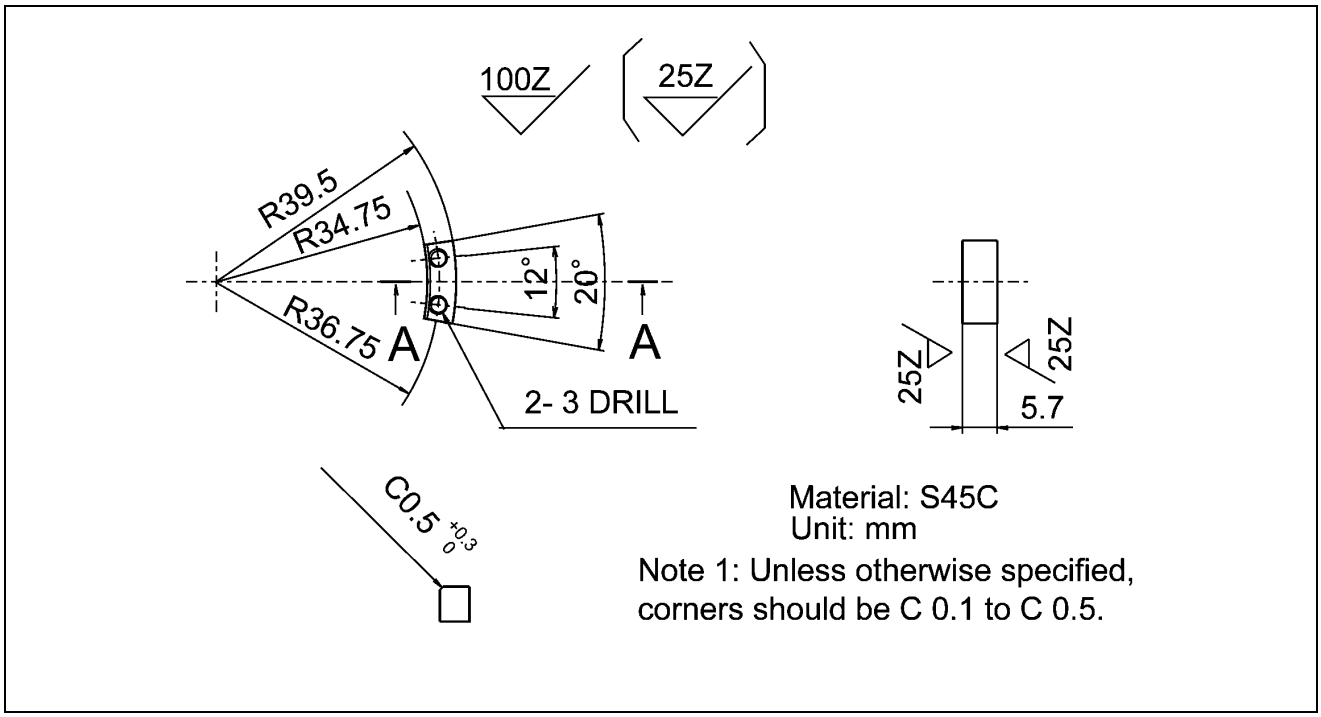
Fix the 2nd-axis stopper to the robot unit using two bolts.

STEP 3

Change the set software motion limits and RANG values by referring the 1st -axis procedures.

2.3.3 The 3rd-axis Mechanical End Change

To change the mechanical end for the 3rd-axis, you need to prepare the mechanical stop shown in the figure below.



Reference drawing for the 3rd-axis mechanical stopper

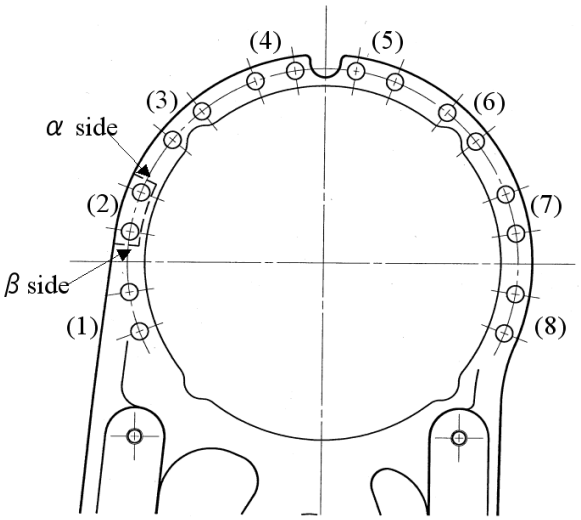
2.3.3.1 The 3rd-axis Mechanical End Change: VP-6242F

The figure below show the mechanical stopper positions when changing the mechanical ends, and their software motion limits (PLIM, NLIM).

The figure below shows the example when mechanical stopper position (2) is used.

In this case, set the software motion limit to the following values. (PLIM: 150 degrees, NLIM: 19 degrees)

Example of changing the 3rd-axis mechanical ends



Software motion limits when changing the 3rd-axis mechanical ends

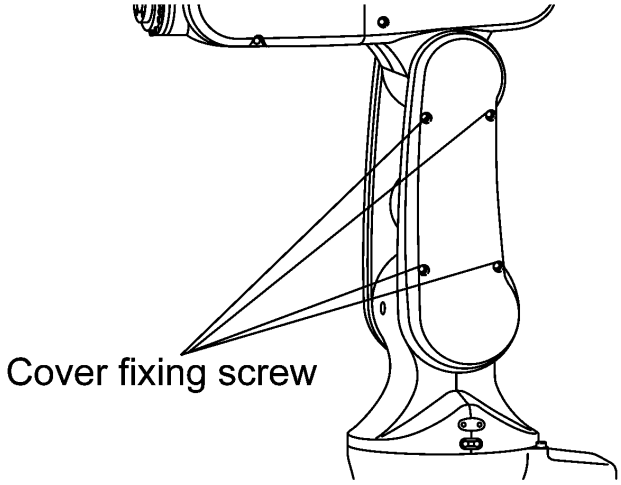
Mechanical stopper position	Touch at α side: Motion range (degrees)	Touch at β side: Motion range (degrees)
Mechanical stopper (1)	–	–
Mechanical stopper (2)	150 to 19	–
Mechanical stopper (3)	120 to 19	150 to 160
Mechanical stopper (4)	90 to 19	120 to 160
Mechanical stopper (5)	60 to 19	90 to 160
Mechanical stopper (6)	30 to 19	60 to 160
Mechanical stopper (7)	–	30 to 160
Mechanical stopper (8)	–	–

The 3rd-axis Mechanical End Change (Examples of VP-6242F)

<Procedures of changing the 3rd-axis mechanical ends: VP-6242F>

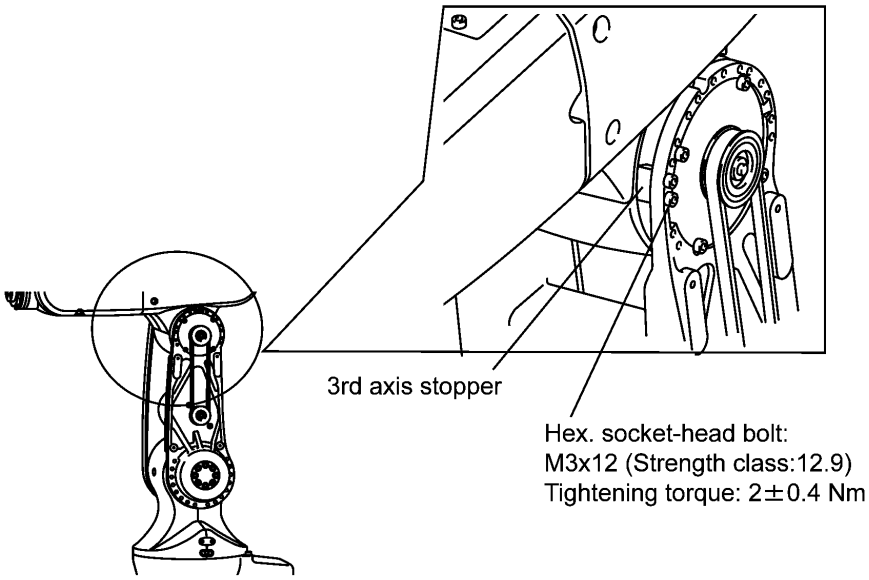
STEP 1

Unscrew four cover-fixing screws and remove the cover.



STEP 2

The figure below shows the example of "Mechanical stopper (2)".



Fix the 3rd-axis stopper to the robot unit using two bolts.

STEP 3

Change the set software motion limits and RANG values by referring the 1st -axis procedures.

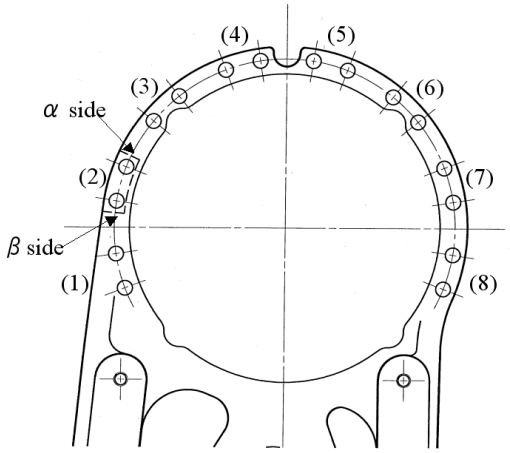
2.3.3.2 The 3rd-axis Mechanical End Change: VP-5243F

The figure below show the mechanical stopper positions when changing the mechanical ends, and their software motion limits (PLIM, NLIM).

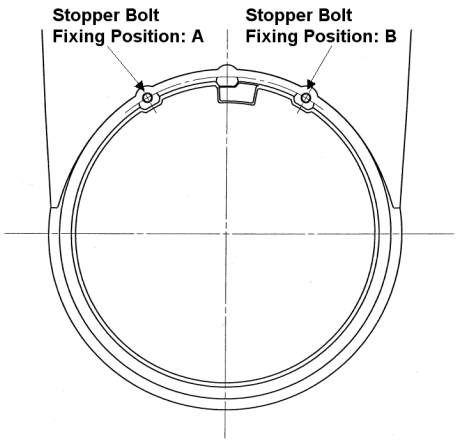
The figure below shows the example when mechanical stopper position (2) is used.

In this case, if the stopper-bolt fixing position is “A”, set the software motion limit to the following values. (PLIM: 60 degrees, NLIM: -128 degrees)

Example of changing the 3rd-axis mechanical ends



Stopper bolt fixing position



Software motion limits when changing the 3rd-axis mechanical ends

< Stopper bolt fixing position: A >

Mechanical stopper position	Touch at α side: Motion range (degrees)	Touch at β side: Motion range (degrees)
none	90 to -128	90 to -128
Mechanical stopper (1)	60 to -128	90
Mechanical stopper (2)	30 to -128	90 to 60
Mechanical stopper (3)	0 to -128	90 to 30
Mechanical stopper (4)	-30 to -128	90 to 0
Mechanical stopper (5)	-60 to -128	90 to -30
Mechanical stopper (6)	-90 to -128	90 to -60
Mechanical stopper (7)	-120 to -128	90 to -90
Mechanical stopper (8)	-	90 to -120

< Stopper bolt fixing position: B >

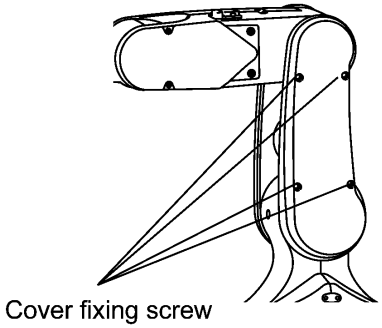
Mechanical stopper position	Touch at α side: Motion range (degrees)	Touch at β side: Motion range (degrees)
Mechanical stopper (1)	120 to -90	-
Mechanical stopper (2)	90 to -90	136 to 120
Mechanical stopper (3)	60 to -90	136 to 90
Mechanical stopper (4)	30 to -90	136 to 60
Mechanical stopper (5)	0 to -90	136 to 30
Mechanical stopper (6)	-30 to -90	136 to 0
Mechanical stopper (7)	-60 to -90	136 to -130
Mechanical stopper (8)	-90	136 to -60
none	136 to -90	136 to -90

The 3rd-axis Mechanical End Change (Examples of VP-5243F)

<Procedures of changing the 3rd-axis mechanical ends: VP-5243F>

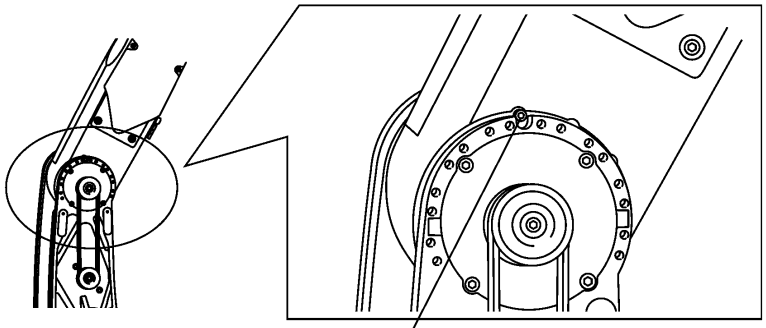
STEP 1

Unscrew four cover-fixing screws and remove the cover.



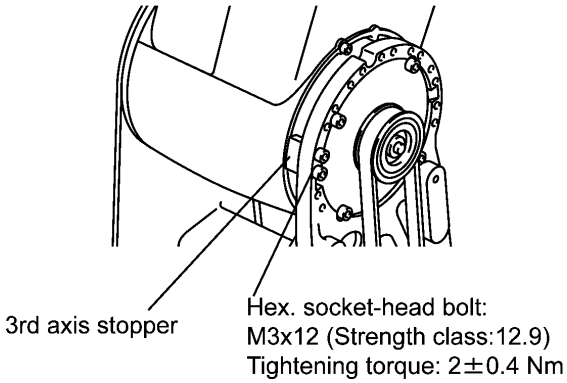
STEP 2

Release the 3rd-axis brake by the teach pendant operation, and move the 3rd-axis to the position that you can see the fixing tap for the stopper bolt on the second arm. And install the stopper bolt on the fixing tap.



STEP 3

The figure below shows the example of the "Stopper position fixing position A".



STEP 4

Change the set software motion limits and RANG values by referring the 1st -axis procedures.

2.4 CALSET

2.4.1 What Is CALSET?

Calibrating the relationship between position-related information recognized by the robot controller and the actual position of the robot unit is called CALSET.

CALSET must be performed when the motor is replaced or when the encoder backup battery goes dead and the position-related data retained in the encoder is lost as a result.

After CALSET is completed, the calibrated data of the robot unit will be stored in the robot controller. This data is called CALSET data which is different on each robot.

This robot has been CALSET before delivery and the CALSET data is stored in the floppy disks that come with the robot unit. Therefore, even if the memory backup battery in the robot controller dies so that the CALSET data is lost, you do not need to CALSET the robot. Just reload the CALSET data from the floppy disks.

2.4.2 Cautions at CALSET

CALSET requires some space for bringing each axis into contact with the mechanical end.

Caution:(1) To CALSET the 6th axis having no mechanical stop, you need to mount the CALSET jig on the axis.

(2) When CALSETing, move the axis to be CALSET in the vicinity of the mechanical stop, release the brake, and bring the axis into contact with the mechanical stop. In the VP-F series, each of all axes has a brake.

(3) When performing CALSET, be careful with the robot motion. The execution of the CALSET command releases motor brakes so that the robot arms will move by its own weight.

(4) After CALSET, confirm in the manual mode that each axis stops at the software motion limit before coming into contact with the mechanical end.

(5) In automatic operation, start to run the robot at low speed. Ensuring safety, gradually increase the speed. It makes adjustment easy.

(6) Position-related data in some programs made before CALSET may vary somewhat after CALSET.

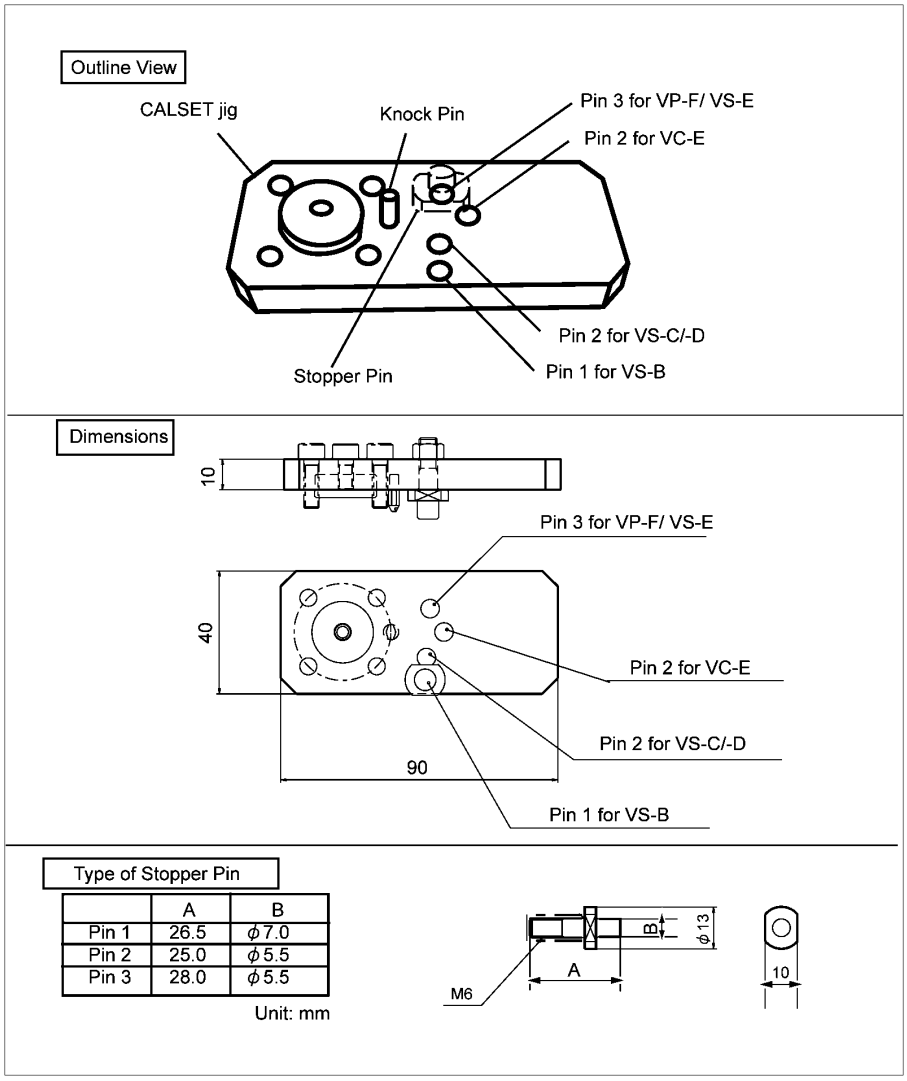
2.4.3 Mounting the CALSET Jig

To CALSET the 6th axis having no mechanical stop, you need to mount the CALSET jig on the axis.

Mounting the CALSET jig on the 6th axis

▸ STEP 1

Fit a stopper pin in the CALSET jig.



	A	B
Pin 1	26.5	ϕ7.0
Pin 2	25.0	ϕ5.5
Pin 3	28.0	ϕ5.5

Unit: mm

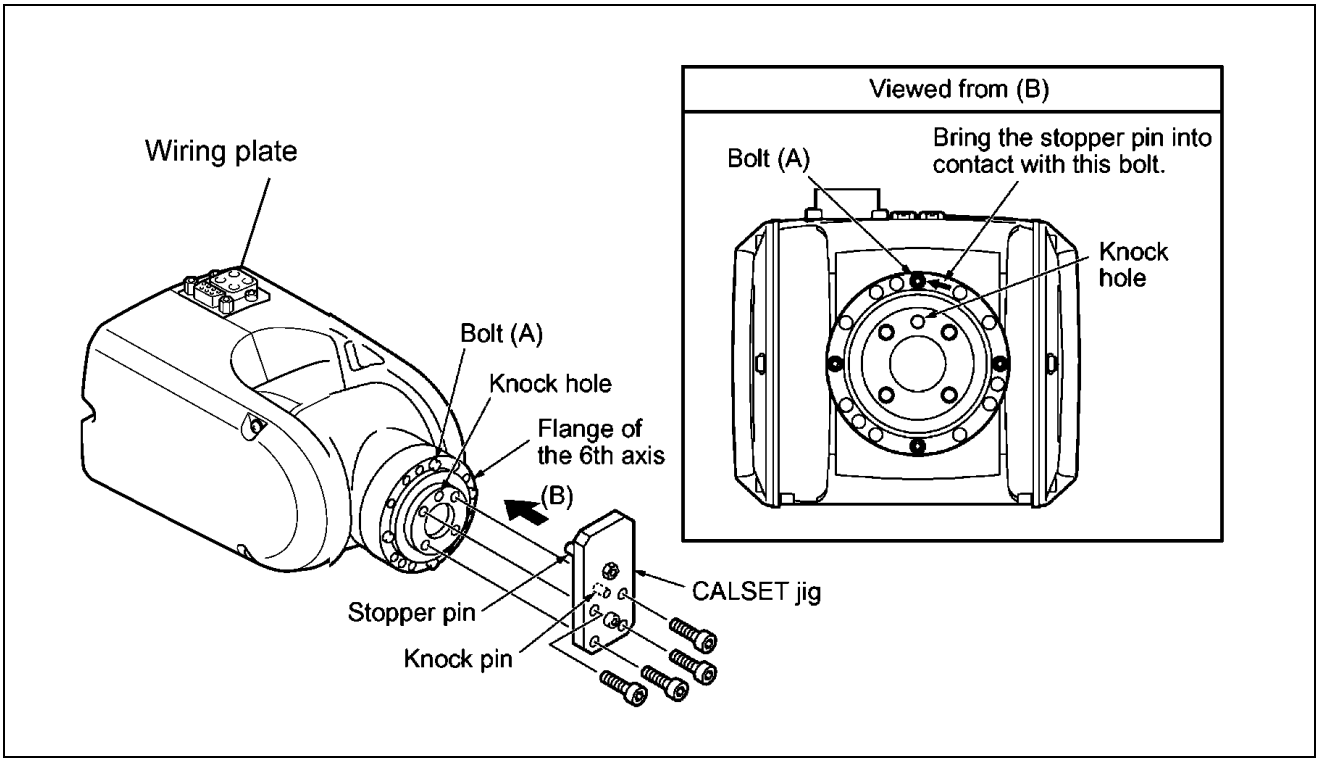
▸ STEP 2

Release the brake of the 6th axis.

STEP 3

Install the CALSET jig on the 6th axis flange as shown in the figure below.

TIP: The CALSET position of the 6th axis refers to the point where the stopper pin (shown in the figure below) comes into contact with bolt (A) by turning the flange of the 6th axis.



Mounting a CALSET Jig

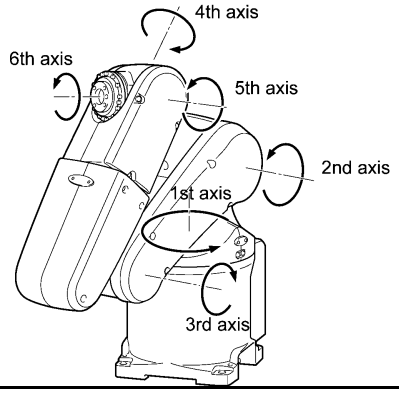
2.4.4 What Is a CALSET Position?

The limit position of an arm to be CALSET is called a CALSET position.

Each axis has a mechanical end in each of the positive and negative directions. The mechanical ends shown in the figure below are the CALSET positions.

<VP-6242F>

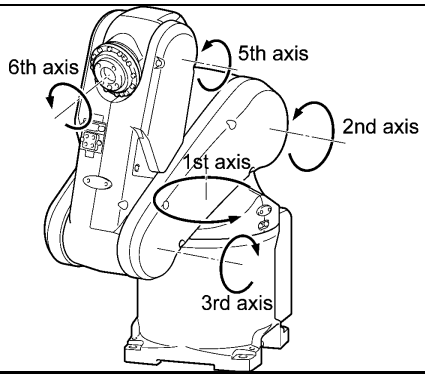
Axis		CALSET position
Position	1st axis	Turning end in the positive direction (counterclockwise end when viewed from top)
	2nd axis	Turning end in the negative direction
	3rd axis	Turning end in the positive direction
	4th axis	Turning end in the positive direction. (counterclockwise end when viewed from the arm end)
	5th axis	Turning end in the positive direction
	6th axis	Turning end in the positive direction, which is set by a CALSET jig. (See Section 2.3.3.)



CALSET Positions (VP-6242F)

<VP-5243F>

Axis		CALSET position
Position	1st axis	Turning end in the positive direction (counterclockwise end when viewed from top)
	2nd axis	Turning end in the negative direction
	3rd axis	Turning end in the positive direction
	5th axis	Turning end in the negative direction
	6th axis	Turning end in the positive direction, which is set by a CALSET jig. (See Section 2.3.3.)



CALSET Positions (VP-5243F)

2.4.5 CALSET Procedure

2.4.5.1 CALSETing a Single Axis

CALSETing a specified single axis only is called single-axis CALSET.

Perform single-axis CALSET if the motor of an axis is replaced so that the axis must be CALSET, or if some axes cannot be moved to the CALSET positions (mechanical stop positions) at any given time because of interference between the robot unit and its surrounding facilities.

▶ STEP 1

Turn the power switch of the robot controller to ON.

▶ STEP 2

Set the mode selector switch of the teach pendant to MANUAL.

▶ STEP 3

Press MOTOR to turn ON the power to the motor.

▶ STEP 4

Move the axis to be CALSET in the vicinity of the mechanical stop via the manual operation from the teach pendant.

▶ STEP 5

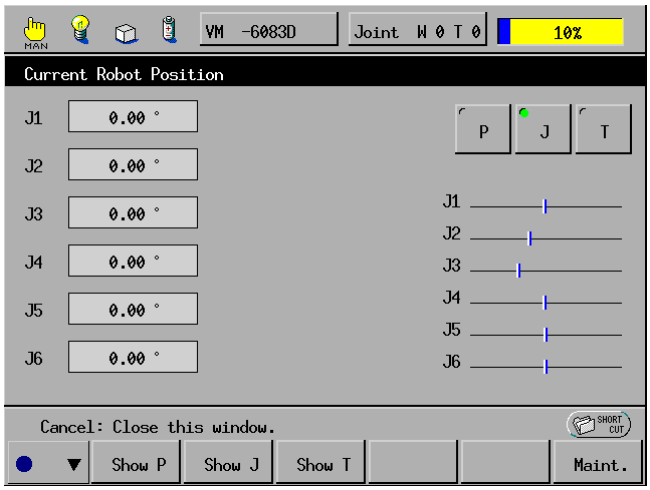
Press the MOTOR key on the teach pendant to turn OFF the power to the motor.

▶ STEP 6

Press [F2 Arm] on the teach pendant.

STEP 7

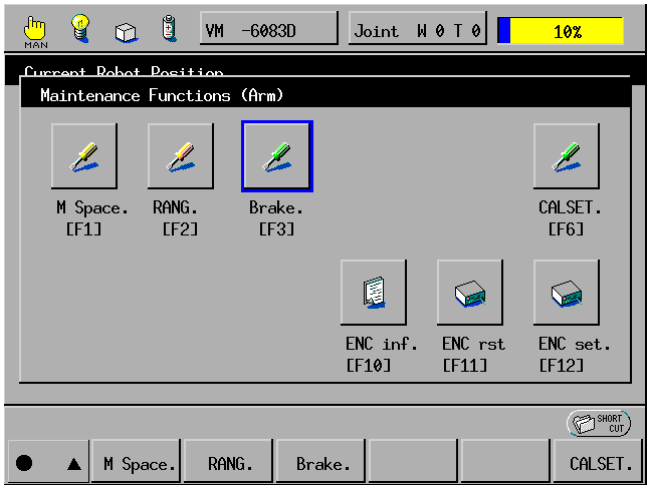
Press the SHIFT key and [F12 Maint.].



F12

STEP 8

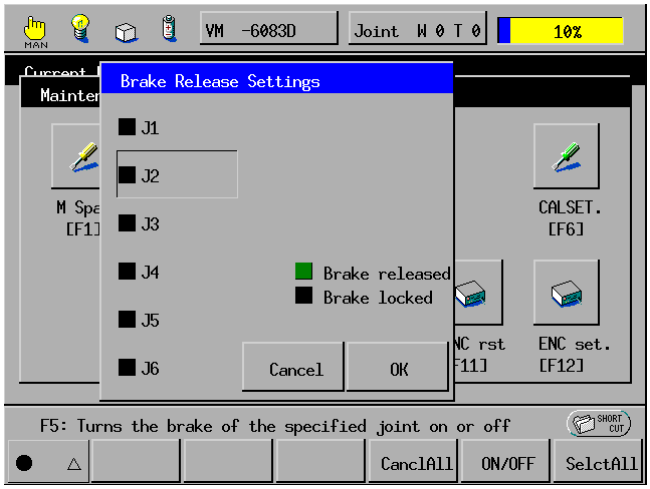
Press [F3 Brake.].



F3

STEP 9

Touch the axis number to be CALSET to select "Brake released" (green display).



STEP 10

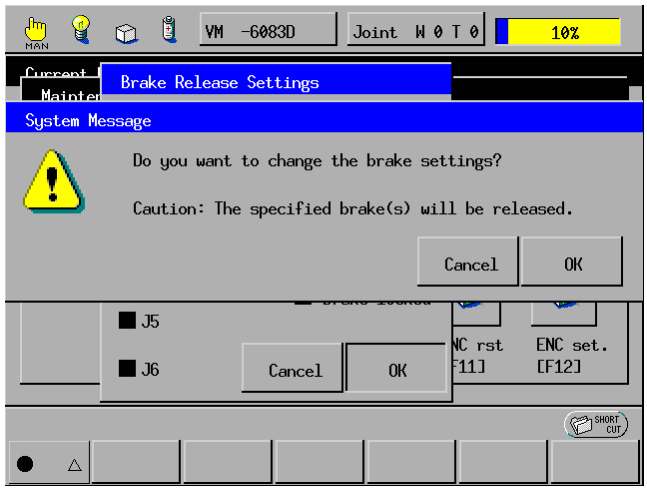
Confirm that there is no danger even if the arms fall as a result of released brakes.

CAUTION: In the VP-F series, the brake of the specified axis is released.

STEP 11

Press OK.

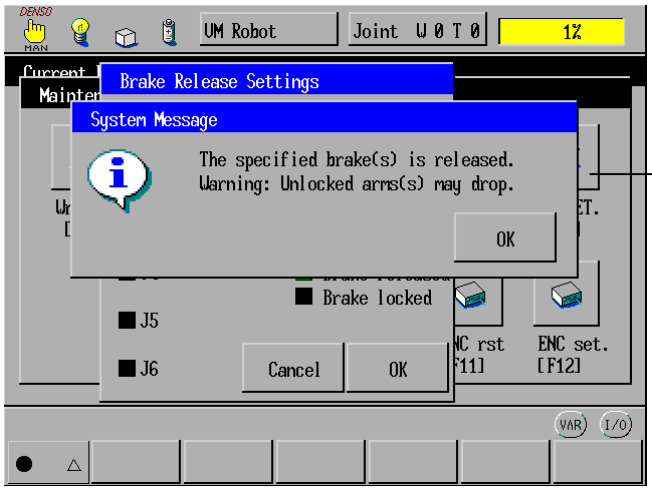
The system message appears asking you whether you want to change the brake settings.



STEP 12

Press OK.

The system message appears informing that the brake is released and warning against drop of arms.



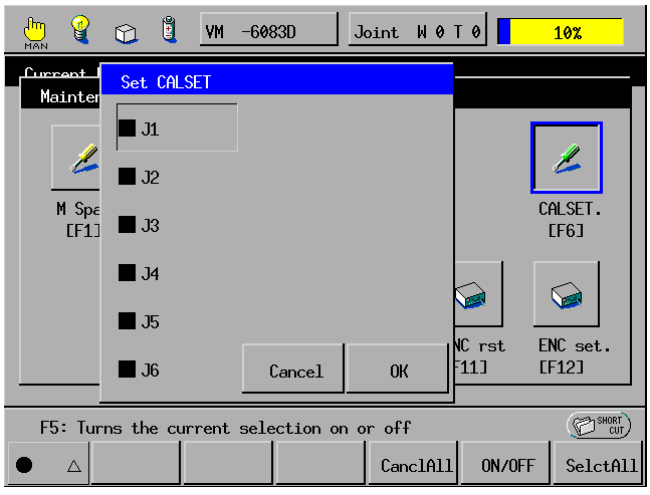
STEP 13

Press the axis to be CALSET against the mechanical stop by hand.

STEP 14

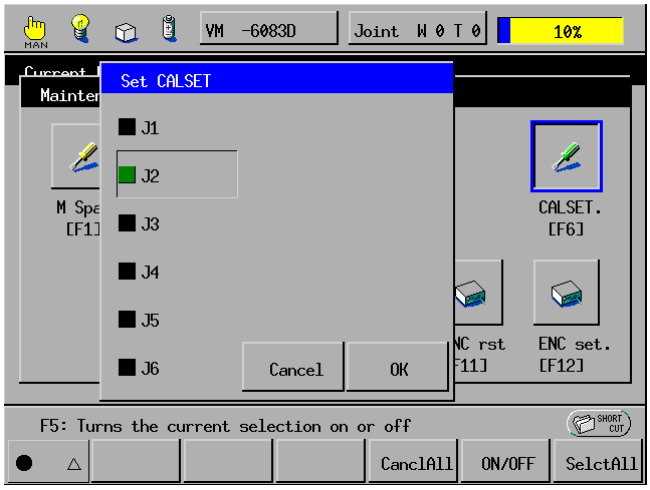
Press [F6 CALSET.].

The Set CALSET window appears.



STEP 15

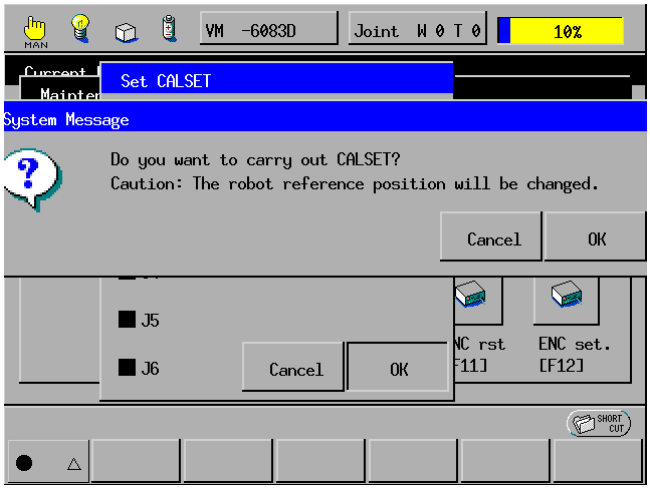
Press the axis number to be CALSET to select CALSET (green display). Deselect CALSET (black display) for the other axes that are not required to be CALSET.



STEP 16

Press OK.

The system message appears asking whether you want to carry out CALSET and showing a caution that the robot reference position will be changed.



STEP 17

Press OK.

The system message appears informing that CALSET is completed.

STEP 18

Press the ROBOT STOP button.

The robot brake becomes activated.

STEP 19

Turn the ROBOT STOP button to cancel robot stop.

STEP 20

Press the MOTOR to turn ON the power to the motor.

Caution: A "motor lock overload" error may occur just after the power to the motor is turned ON. In this case, try to turn ON the power several times, or release the brake, move the axis a little in the opposite direction of the mechanical end, and turn ON the power again.

STEP 21

Move the CALSETed axis in the opposite direction from the mechanical end by the manual operation of the teach pendant.

STEP 22

Perform CAL. The single-axis CALSET of the specified axis is completed.

2.4.5.2 CALSETing All Axes

The CALSET of all axes is called all-axis CALSET.

The procedure is the same as that for single-axis CALSET except that you should select all axes for brake release and CALSET in Steps 9 and 15. For details of the procedure, see Subsection 2.3.5.1 "CALSETing a Single Axis."

2.5 Setting Control Set of Motion Optimization

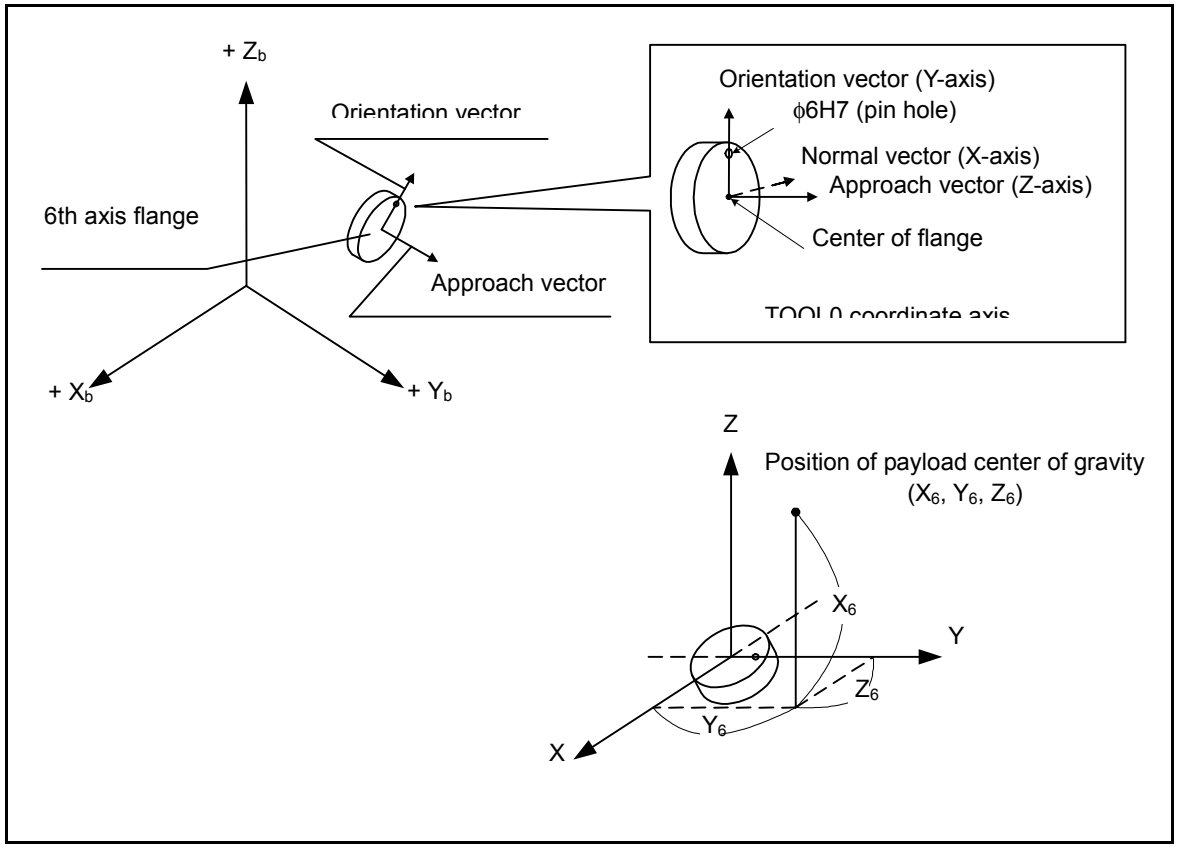
The optimum speed or acceleration will vary depending upon the payload and center of gravity of an end-effector or workpiece that is to be set at the end of the robot flange. Set the payload and center of gravity position of the end-effector or workpiece and the control set of motion optimization according to the payload and robot posture.

The mass of payload is a total mass of an end-effector and workpiece, expressed in grams.

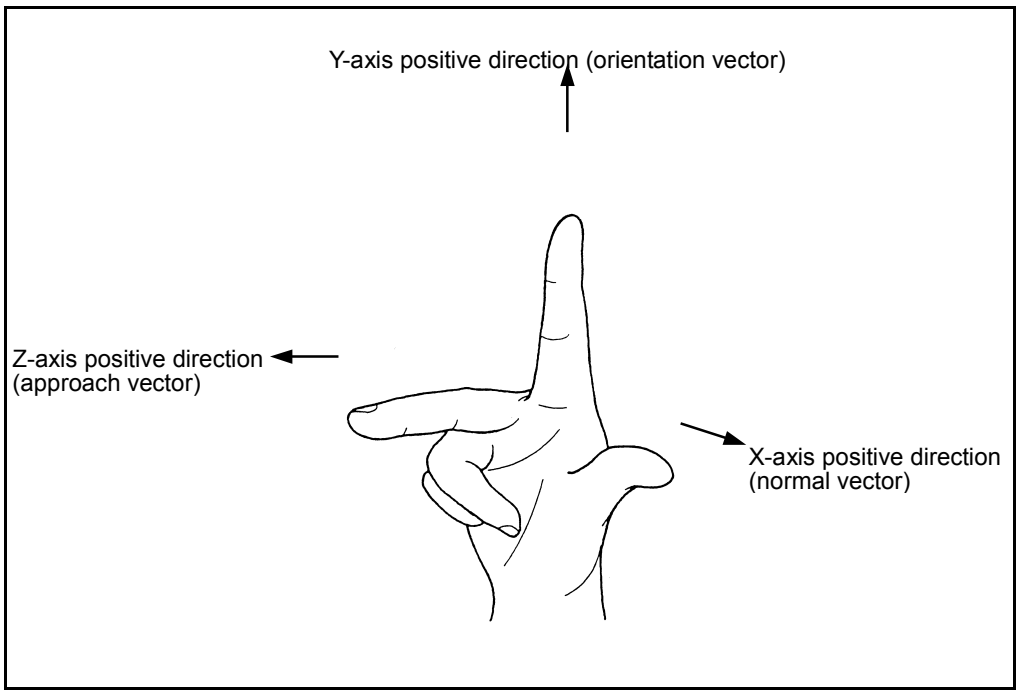
For further information, see the PROGRAMMER'S MANUAL, Section 4.7 "Setting the Master Control Parameters in User Preferences." For the setting procedure, refer to the SETTING-UP MANUAL, Section 2.9, "Setting the Master Control Parameters of the Payload, Center of Gravity, and Control Set of Motion Optimization."

The payload center of gravity is represented by the TOOL0 coordinate system (see the figure below) in the unit of mm.

The origin of the TOOL0 coordinate system is the center of the 6th axis flange. Its Y-component is in the direction from the flange center to the ϕ6H7 pin hole (orientation vector direction). The Z-component is in the vertical direction to the flange face across the flange center (approach vector direction). The X-component is in the X-axis direction of the right hand coordinate system (normal vector direction) with the orientation vector as the Y-axis and the approach vector as the Z-axis. (See the figure on the next page.)



Payload Center of Gravity



Right Hand Coordinate System

2.6 Setting Robot Installation Conditions

The optimum operating conditions will differ depending on whether the robot is floor-mounted or overhead-mounted.

When the robot leaves the factory, it is set for floor-mount. If you overhead-mount your robot, you need to change the installation settings.

For the setting procedure, refer to the SETTING-UP MANUAL, Section 2.10, "Setting the Robot Installation Condition" and the PROGRAMMER'S MANUAL, Subsection 4.7.3 "Setting Robot Installation Conditions."

Chapter 3 Maintenance and Inspection

3.1 Maintenance & Inspection Intervals and Purposes

Carry out the maintenance and inspection jobs show in the table below.

> ⚠**Caution: Before performing maintenance and inspection jobs, read the SAFETY PRECAUTIONS, "3 Precautions while robot is running" and "4 Daily and periodical inspections."**

Maintenance & Inspection Intervals and Purposes

No.	Intervals		Purposes
1	Daily	Perform inspection jobs specified in Section 3.2 every day before starting operations.	To use your robot safely.
2	Quarterly	Perform inspection jobs specified in Section 3.3 every three months.	To maintain the precision of the robot and to prevent failures caused by overheat of the robot controller.
3	Biennial	Replace backup batteries as specified in Section 3.4 every two years.	To retain the robot-specific data (programs, parameters, etc.) stored in the internal memory of the robot controller and the position data stored in the electronic absolute encoder build in the robot unit.
		Check the timing belts on the 3rd and 5th axes as specified in Section 3.4 every two years.	To prevent the belt from the lack of teeth or excessive wear.

3.2 Daily Inspections

3.2.1 Check Items

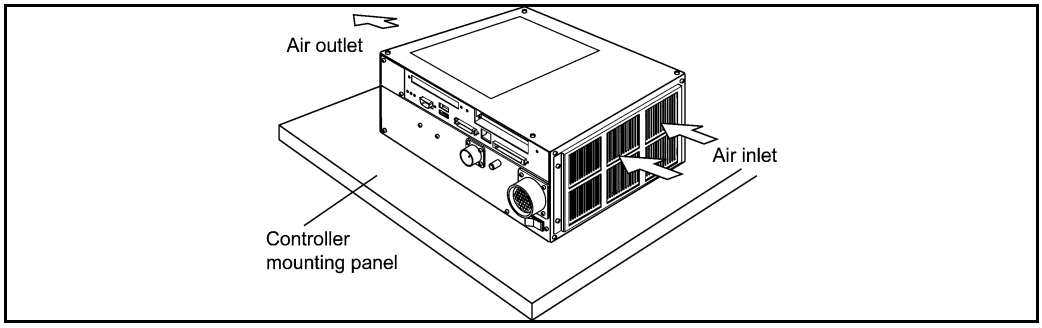
Before starting operation every day, check the items listed in the table below.

Daily Inspections Table

No.	Check:	Controller Power	How to check:	Criterion	What to do: (Note 1)
1	Connectors (CN1 to CN12 on the robot controller) and their mating parts	OFF	Visually	No looseness, disengagement or dirt.	Engage the parts properly and clean them.
2	Cables (connected to CN1 to CN12 on the robot controller) and robot's external cables	OFF	Visually	Free of damage or gouges.	Repair or replace.
3	LCD on the teach pendant	ON	Visually	Properly displayed	Repair or replace.
4	Pilot lamps on the robot controller	ON	Visually	Should light.	Repair or replace.
5	Cooling fan in the robot controller	ON	Visually **(Note 2)**	Should work properly.	Repair or replace.
6	Calibration	ON	Visually	No error or unusual noise.	Repair or replace.
7	ROBOT STOP button on the teach pendant or the mini pendant	ON	Press the ROBOT STOP button.	The robot should come to an emergency stop.	Repair or replace.
8	Safety door	ON	Operate the safety door switch and open the switch-wiring door.	The robot should come to an emergency stop.	Repair or replace.

Note 1 Some repair and replacement operations, shown in "What to do:" column, may involve special work. Contact our Robot Service Section.

Note 2 The normal operation of the cooling fan is as shown in the figure on the next page.



Normal Operation of Cooling Fan

3.3 Quarterly Inspections

3.3.1 Check Items

Check the items listed in the table below every three months.

Quarterly Inspections Table

No.	Check:	Controller Power	How to check:	Criterion	What to do:
1	Robot base mounting bolts	OFF	Measure the tightening torque with a torque wrench.	No looseness. Specified torque: 35 ± 7 Nm	Tighten the bolts to the specified torque.
2	Cooling fan filters in the robot controller	OFF	Visually	No dust or dirt.	Clean the cooling fan filters. (Refer to Subsect. 3.3.2.)

3.3.2 Cleaning the Air Intake Filter in the Robot Controller

For the cleaning procedures of the air intake filter, refer to the " Section 6.4 Cleaning the Air Intake Filter, RC7J CONTROLLER INTERFACE MANUAL".

3.4 Biennial Inspections

3.4.1 Battery Replacement and Belt Inspection

Replace the two types of backup batteries listed in the upper table on this page and inspect the timing belts for the 3rd and 5th axes shown in the lower table on this page during biannual inspection and maintenance.

Backup Battery Types

	Battery type	Used to:	Located:	Refer to:
1	Encoder backup battery	Back up the position data of the servomotor encoder.	In the robot unit	Subsect. 3.4.2
2	Memory backup battery	Back up programs, parameters, and CAL data.	In the robot controller	Subsect. 3.4.3

The position data of the encoder built in the servomotor is stored in the internal memory of the encoder.

Programs, parameters, CAL data, etc. are stored in the internal memory of the robot controller.

The backup battery for each memory retains the above data while the power to the robot controller is turned OFF. However, these batteries have a limited lifetime and must, therefore, be replaced regularly.

NOTE: If two years elapse from replacement of either backup battery, the "Time to change controller backup battery" message will appear on the teach pendant.

⚠Caution: Without replacing the backup batteries, important robot-specific data stored in each memory will be lost.

Inspection of Timing Belts

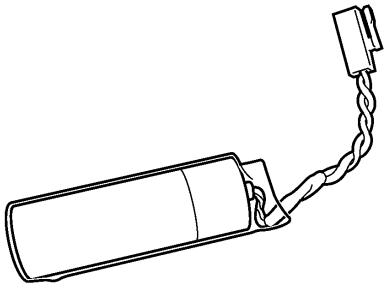
No.	Check:	Controller Power	How to check:	Criterion	What to do:
1	Timing belts on the 3rd and 5th axes	OFF	Visually	No lack of teeth or excessive wear.	Contact our Robot Service Section.

3.4.2 Replacing the Encoder Backup Battery

Replace the encoder backup battery according to the procedure below.

▸ STEP 1

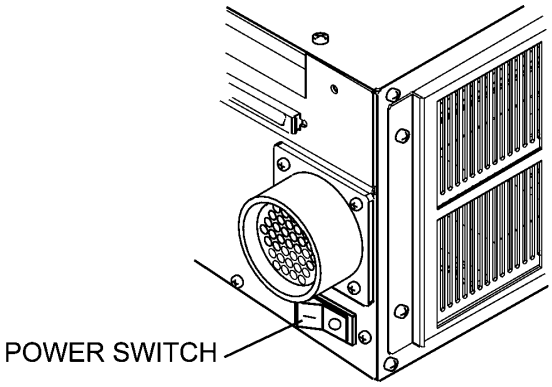
Prepare a new set of 3 backup batteries for replacement.



▸ STEP 2

Turn the controller power ON.

> **Note:** When replacing the encoder backup battery, do not turn the controller power OFF. If you do so, the encoder positional data may be lost.



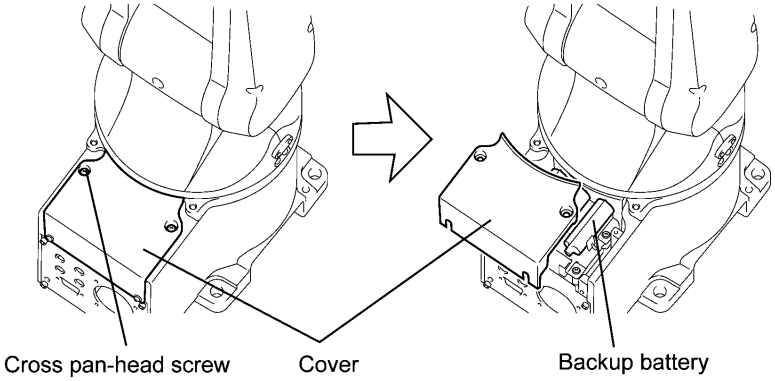
▸ STEP 3

Turn the motor power OFF when replacing the battery.

> **Note:** (1) Push the ROBOT STOP button on the teach pendant or mini pendant, and the button is locked in the stop status.
> (2) When rotating the ROBOT STOP button clockwise, the button will be released.

▸ STEP 4

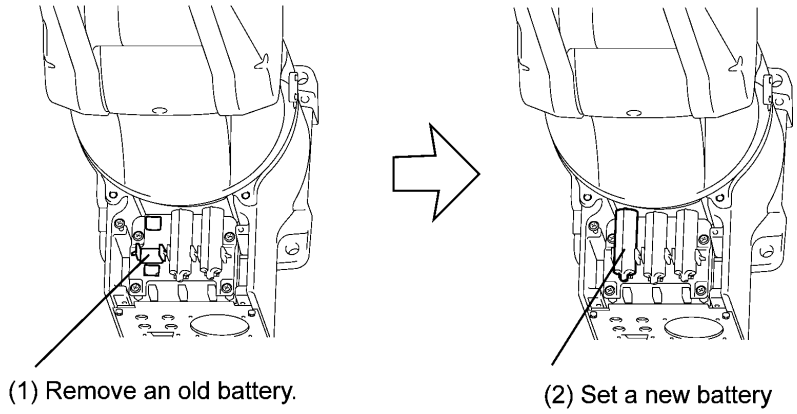
Remove the cover from the robot unit.



▸ STEP 5

Replace an old battery with new one, one by one.

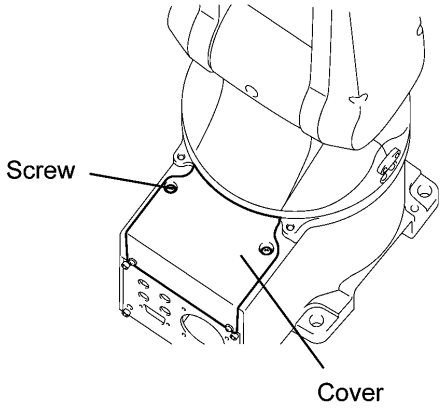
Note: Do not disconnect all old batteries at the same time before connecting a new one. If you do so, the encoder positional data may be lost.



Note: Be sure to replace all of three batteries with new ones at one time. Otherwise, the battery service life will become short.

▸ STEP 6

Reinstall the cover to the robot unit.



Tightening torque:
Cross pan-head screw: 0.59 Nm

3.4.3 Replacing the Memory Backup Battery

For the replacing procedures of the memory backup battery, refer to the " Section 6.5 Replacing the Memory Backup battery, RC7J CONTROLLER INTERFACE MNUAL".

3.4.4 Setting the Next Battery Replacement Date

After replacing the memory backup battery, set the next battery replacement date from the teach pendant, according to the following procedure.

NOTE: This procedure cannot be performed with the mini pendant.

NOTE: Check that the system clock of the robot controller shows the correct date beforehand. If it is incorrect, the next replacement date will also become incorrect.

▶ STEP 1

On the top screen of the teach pendant, press [F6 Set].
The Settings (Main) window appears.

▶ STEP 2

Press [F6 Maint.] in the Settings (Main) window.
The Maintenance menu appears.

▶ STEP 3

Press [F4 Battery] in the Maintenance menu.
The Next Battery Replacement Date window appears.

In the top of the window, the current setting is displayed.

The date entry areas show the default replacement date that is two years later the current data at which you open this window, assuming that the battery service life is two years.

▶ STEP 4

Press OK.

NOTE: If you do not want to change the replacement date, press Cancel.

The message "Are you sure you want to set the next battery replacement date?" appears.

▶ STEP 5

Press OK.
The screen returns to the Settings (Main) window.

3.5 Supplies and Tools

The table below shows the supplies out of components used in DENSO robots that require periodic replacement and the tools recommended for maintenance and inspection.

List of Supplies and Tools Required

No	Name	Part No.	Remarks
1	Filter	410041-4730	Air intake filter in the robot controller
2	Memory backup battery	410076-0260	Memory backup battery for controller
3	Encoder backup battery	410611-0070	3-battery set
4	Fuse (1.3A)	410054-0230	Fuse LM13 (1.3A) for controller I/O
5	Fuse (0.3A)	410054-0240	Fuse LM03 (0.3A) for controller I/O
6	IC for output (NPN)	410077-0010	IC (M54522P) for controller output
7	IC for output (PNP)	410077-0020	IC (M54564P) for controller output
8	CALSET jig	410192-0010	For 6th-axis CALSET

3.6 Replacing Fuses and Output ICs

For the replacing procedures of the fuses and output ICs, refer to the “ Section 6.6 Replacing Fuses and Output ICs, RC7J CONTROLLER INTERFACE MNUAL”.

3.7 Checking the Odometer and Trip Meter

You may check the odometer and trip meter which count traversed distance of each axis in the Odometer window of the teach pendant. With the trip meter, you may learn when oil change should be made.

The access to the Odometer window is [F6 Set]—[F6 Maint.]—[F5 Odometer].

The Odometer window shows the following items:

[Odometer]	Shows the total distance of each axis traversed after the robot leaves the factory. You cannot reset the odometer.
[Trip meter]	Shows the distance of each axis traversed after you reset the trip meter to zero.
[Interval]	Shows the oil change intervals specified for each axis, as a guide.

3.7.1 Displaying the Odometer, Trip Meter, and Oil Change Intervals

STEP 1

Turn the controller power ON.

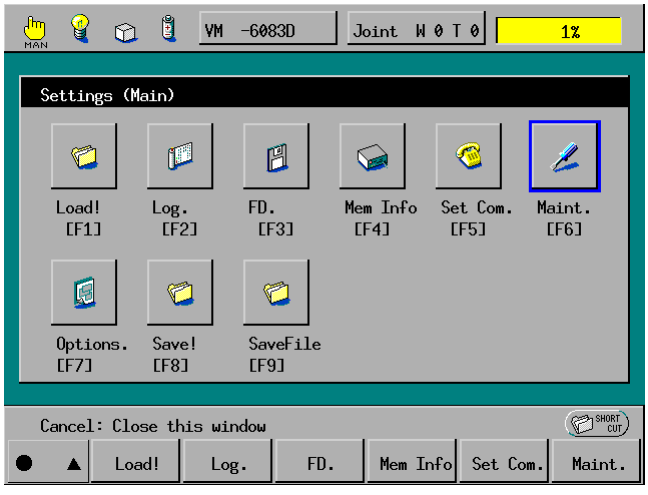
STEP 2

On the teach pendant, set the mode switch to the MANUAL position.

STEP 3

On the top screen, press [F6 Set].

The Settings (Main) window appears as shown below.

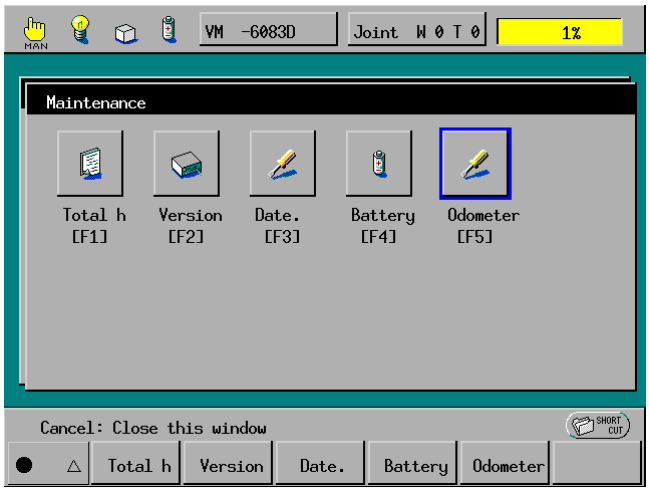


F6

Press [F6 Maint.].

STEP 4

The Maintenance menu appears as shown below.

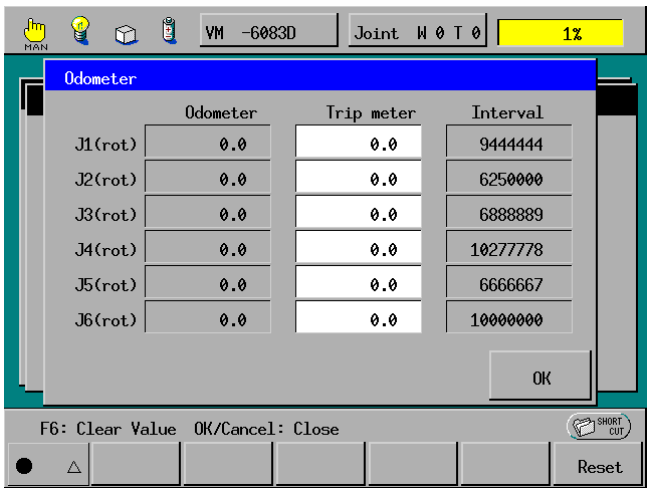


F5

Press [F5 Odometer].

STEP 5

The Odometer window appears as shown below.



F6

In the above Odometer window, the J1 through J6 are expressed in rpm.

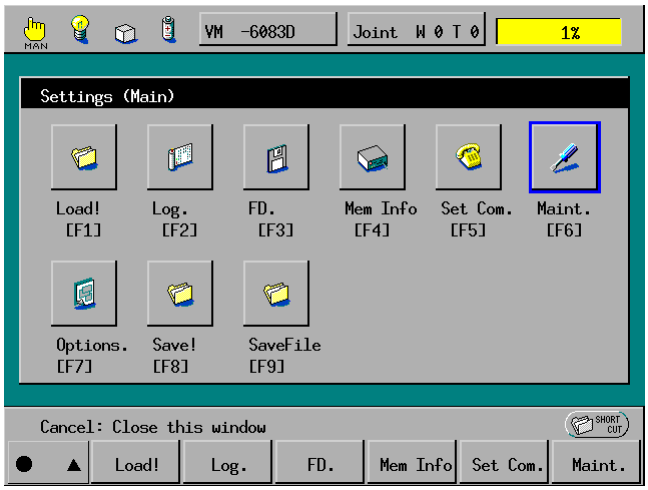
If the Trip meter count exceeds the Interval value, the oil change prompt message will appear.

3.7.2 Resetting the Trip Meter to Zero

▸ STEP 1

On the top screen, press [F6 Set].

The Settings (Main) window appears as shown below.

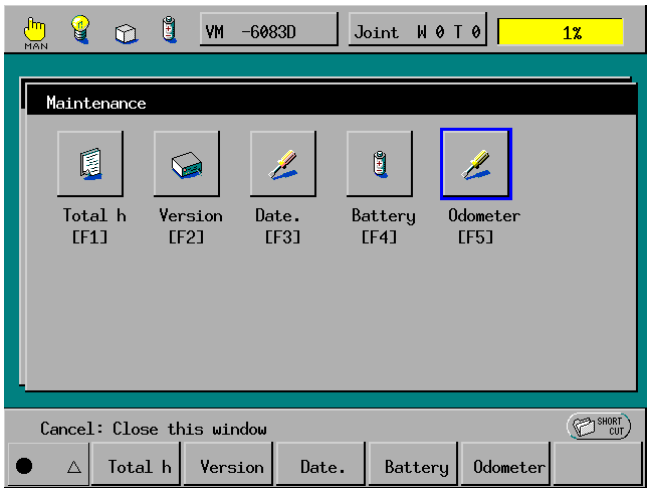


F6

Press [F6 Maint.].

▸ STEP 2

The Maintenance menu appears as shown below.

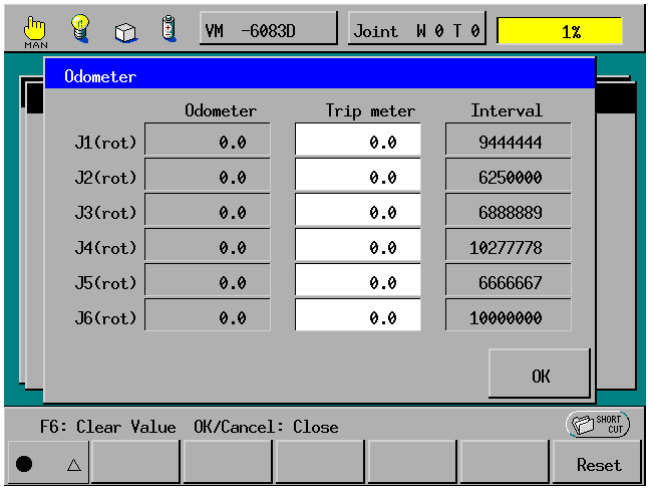


F5

Press [F5 Odometer].

STEP 3

The Odometer window appears as shown below.

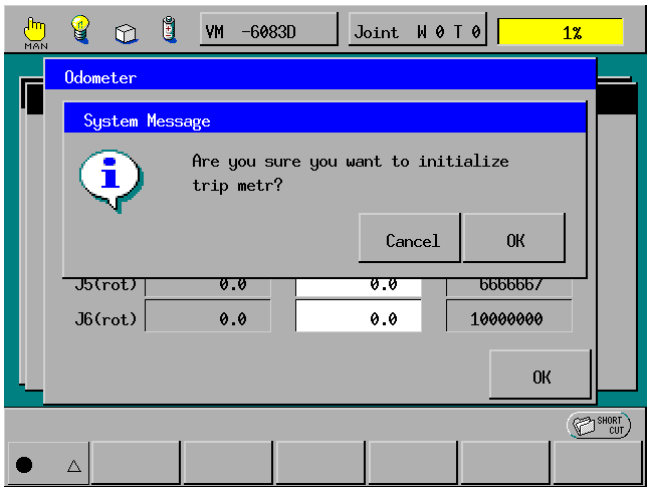


F6

Press [F6 Reset].

STEP 4

The following message appears.



Press the OK button.

The trip meter has been reset to zero.

3.8 Checking the Controller ON-Time and the Robot Running Time and Resetting Their User Counters

You may check the robot controller ON-time and the robot running time in the Total hours window of the teach pendant.

The Total hours window shows the following items:

[Total operation]	Shows the grand total of the robot controller ON-time counted after the controller leaves the factory.
[Total running]	Shows the grand total of the robot running time counted after the robot leaves the factory.
[Cumu. operation]	Shows the total of the robot controller ON-time counted after you reset the user counter to zero.
[Cumu. running]	Shows the total of the robot running time counted after you reset the user counter to zero.
[Operation]	Shows the ON-time of the robot controller counted after it is turned ON this time.
[Running]	Shows the running time of the robot counted after the robot controller is turned ON this time.

3.8.1 Displaying the Controller ON-time and the Robot Running Time

▶ STEP 1

Turn the robot controller power ON.

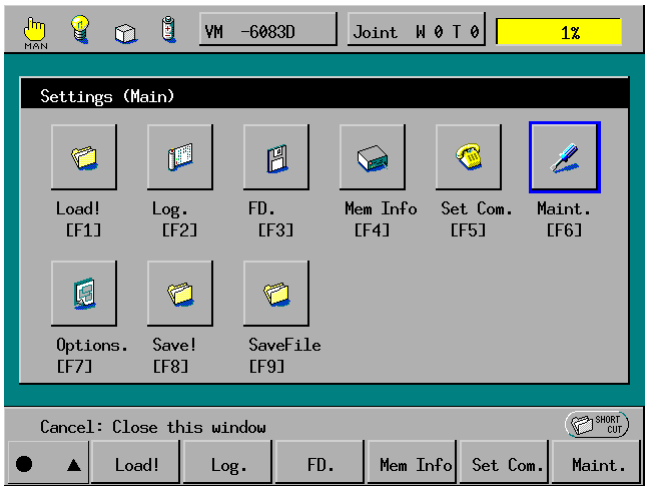
▶ STEP 2

On the teach pendant, set the mode switch to the MANUAL position.

▶ STEP 3

On the top screen, press [F6 Set].

The Settings (Main) window appears as shown below.

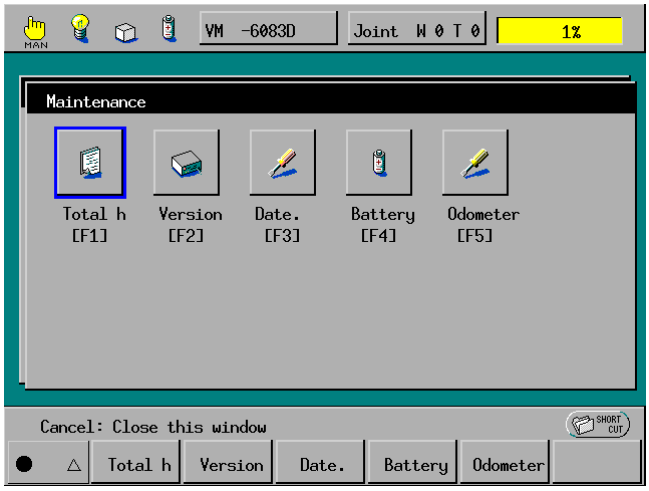


F6

Press [F6 Maint.].

STEP 4

The Maintenance menu appears as shown below.

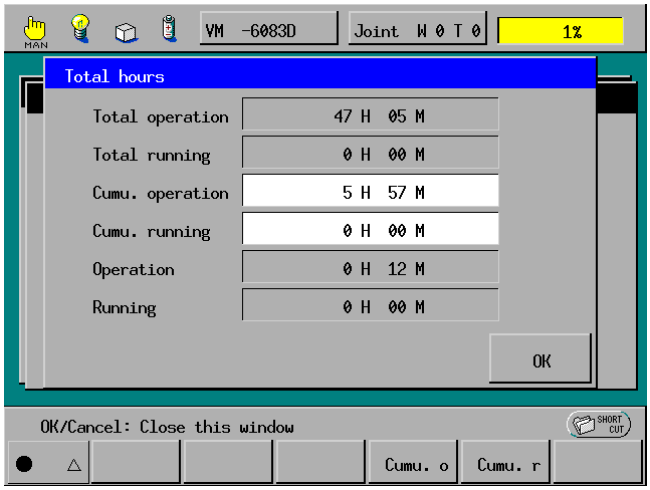


F1

Press [F1 Total h].

STEP 5

The Total hours window appears as shown below.

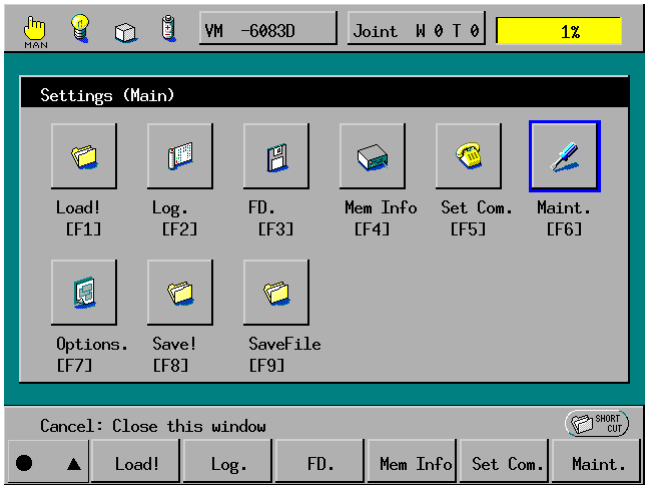


3.8.2 Resetting the User Counters of the Controller ON-Time and the Robot Running Time

STEP 1

On the teach pendant, press [F6 Set].

The Settings (Main) window appears as shown below.

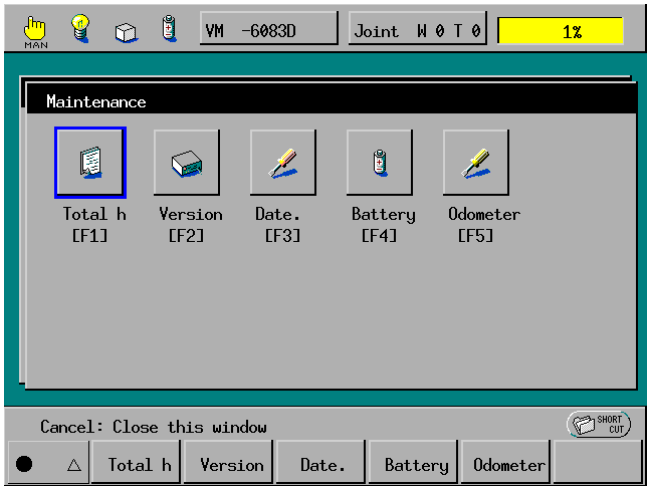


F6

Press [F6 Maint.].

STEP 2

The Maintenance menu appears as shown below.

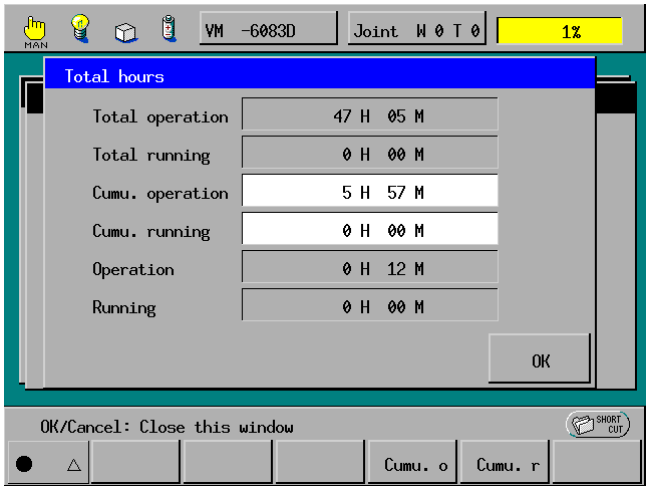


F1

Press [F1 Total h].

STEP 3

The Total hours window appears as shown below.

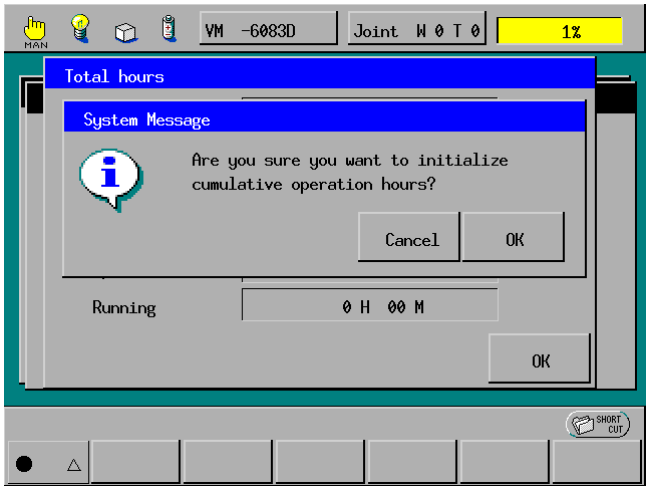


F4

To reset the user counter of the controller ON-time to zero, press [F4 Cumu. o].

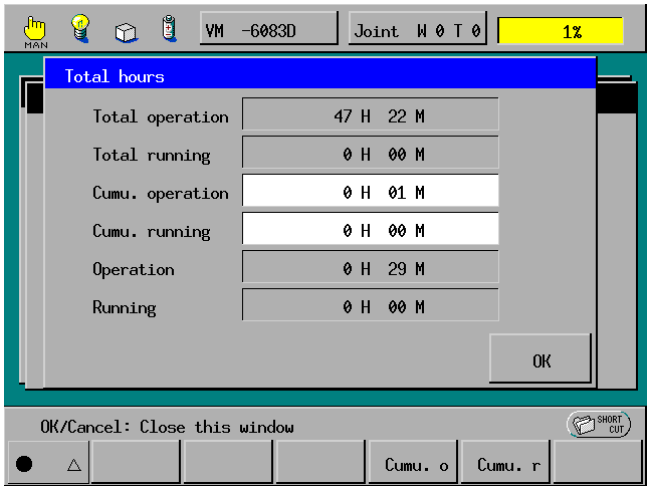
STEP 4

The following system message appears.



Press the OK button.

The user counter of the controller ON-time has been reset to zero.



3.9 Resetting Encoders

You need to reset encoders and perform CALSET if:

- Error 641* occurs due to run-down encoder backup batteries, or
- Error 677* occurs due to a great impact applied to the robot when the power is off.

(* is any of 1 to 6 denoting the object axis.)

This section describes how to reset encoders.

For the encoder resetting procedure, refer to the “SETTING-UP MANUAL, Section 5.3, [F2 Arm]-[F12 Maint.]-[M11 ENC rest]”.

3.10 Using the Initialization Floppy Disk

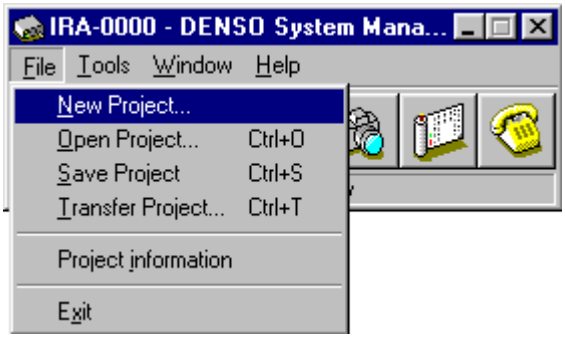
The initialization floppy disk (*.arm) stores arm data in WINCAPSII format.
You transfer the stored arm data to the robot controller in these two steps:
(1) Create a project by using the data stored in the floppy disk.
(2) Transfer the trajectory generation file in the project to the robot controller.

Creating a project to be transferred

▸ STEP 1

Create a new project.

Start WINCAPSII. From the File menu of System Manager, click the New Project.

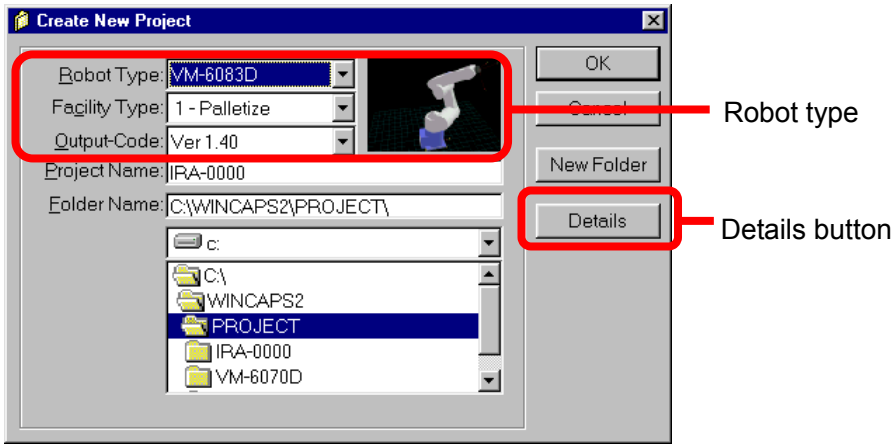


[File menu: Creating a new project]

▸ STEP 2

Select your robot type.

Select the robot type of the controller to which you want to transfer data.

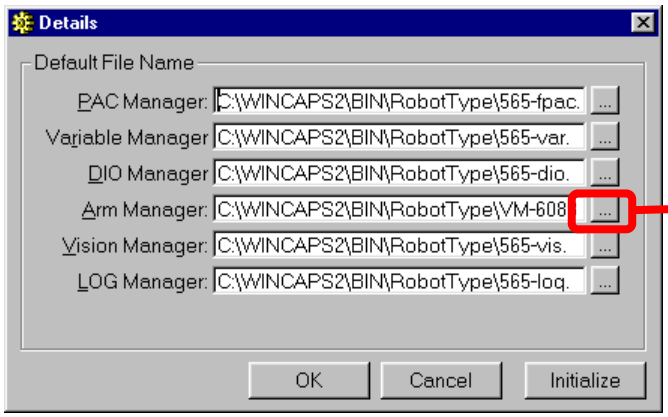


[Create New Project window]

▸ STEP 3

Select arm data.

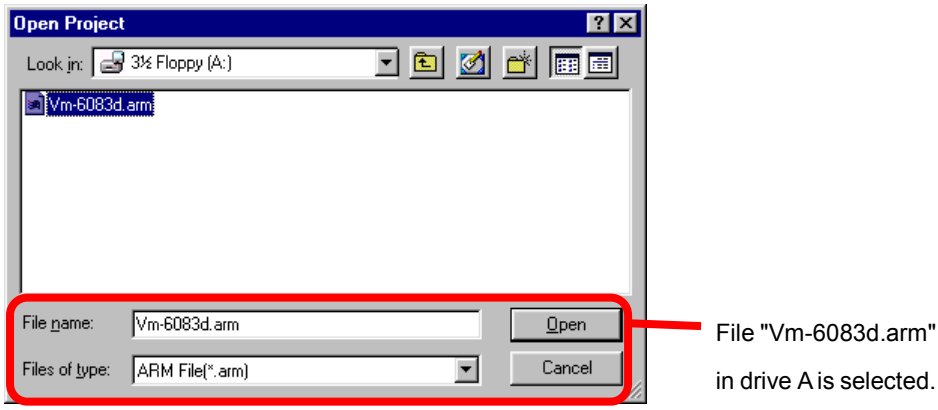
(1) Press the Details button to call up the window below.



[Details window]

(2) Press the Browse button in Arm Manager to call up the Open Project window.

Select desired file in the floppy disk, then press the Open button.



[Selecting a file]

(3) The screen will return to the Details window where you press OK button.

▸ STEP 4

Create a project.

On the Create New Project window, press OK button. Now, a project to be transferred has been created.

Transferring the trajectory generation file

STEP 1

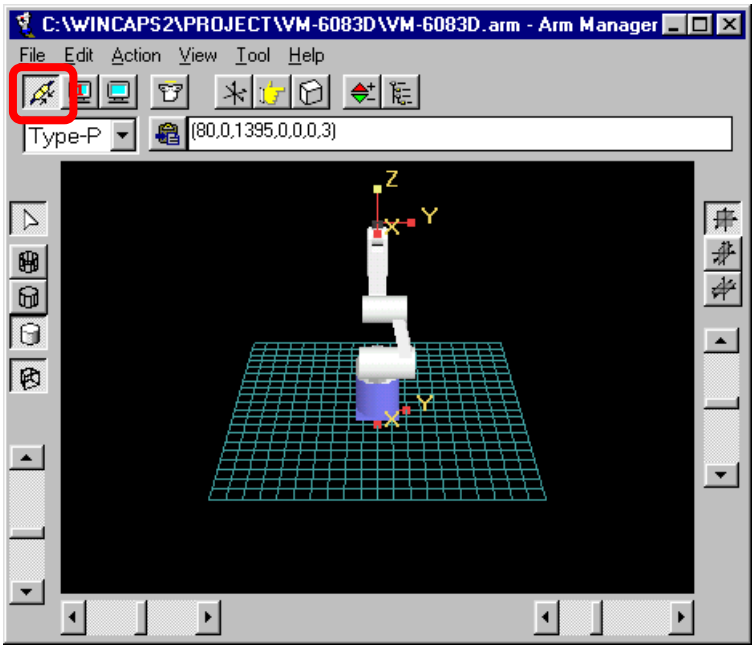
Start of Arm Manager

From System Manager, run Arm Manager.

STEP 2

Connection with the robot controller

Press the Connect button to connect with the robot controller.

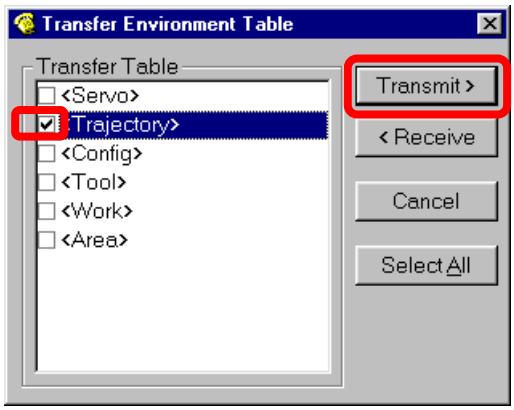


[Arm Manager window]

STEP 3

Data transmission

(1) From the File menu of Arm Manager window, click Transfer command. The Transfer Environment Table appears as shown below.

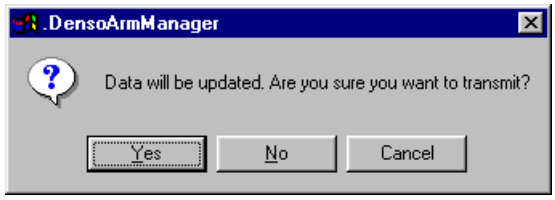


[Transfer Environment Table]

(2) On the table shown above, select the Trajectory and press the Transmit> button.

(3) The following message appears.

Press Yes.



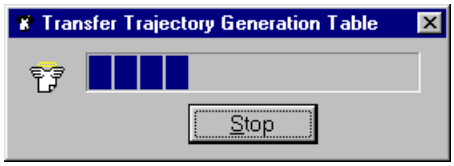
[Confirmation dialog]

The following message appears.

Press OK.

[Configuration transfer dialog]

During data transfer, the following dialog is displayed.



[Transfer Trajectory Generation Table]

(4) Upon completion of transfer, the following message appears.

Press OK.

The arm data stored in the initialization floppy disk has been transferred to the robot controller.

Turn the controller power off and then on.

[Transfer completion message]

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Factory Automation Division
11F20C

The purpose of this manual is to provide accurate information in the handling and operating of the robot. Please feed free to send your comments regarding any errors or omissions you may have found, or any suggestions you may have for generally improving the manual.

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