DENSO ROBOT

Vertical articulated

VP-G SERIES

GENERAL INFORMATION ABOUT ROBOT

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-G (Models configured with RC7M controller)	VP-6242G (6-axis type) VP-5243G (5-axis 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-6242G, for example, the robot unit model is VP-6242E/GM.

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 - this book -

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

INSTALLATION & MAINTENANCE GUIDE

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

STARTUP HANDBOOK

Introduces you to the DENSO robot system and guides you through connecting the robot unit and controller with each other, running the robot with the teach pendant, and making and verifying a program. This manual is a comprehensive guide to starting up your robot system.

SETTING-UP MANUAL

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

For the panel designer functions, refer to the Panel Designer User's Manual (SUPPLEMENT).

WINCAPSIII GUIDE

Provides instructions on how to use the programming support tool WINCAPSIII which runs on the PC connected to the robot controller for developing and managing programs.

PROGRAMMER'S MANUAL I, Program Design and Commands

Describes the PAC programming language, program development, and command specifications in PAC. This manual consists of two parts; Part 1 provides the basic programming knowledge, and Part 2, details of individual commands.

PROGRAMMER'S MANUAL II, PAC Library

Describes the program libraries that come with WINCAPSIII as standard.

RC7M CONTROLLER MANUAL

Provides the specifications, installation and maintenance of the RC7M controller. It also describes 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 or mini-pendant if an error occurs in the robot system. These tables also provide detailed description and recovery ways.

OPTIONS MANUAL

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

For the extension board "conveyer tracking board," refer to the OPTIONS MANUAL (SUPPLEMENT).

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 five, and appendix.

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 Packing List of the Robot
Lists the standard components contained in the product package and optional components.

Chapter 2 Configuration of the Robot System
Illustrates the configuration of the robot system and describes the component names of the robot unit and controller.

Chapter 3 Specifications of the Robot Unit
Describes the specifications, motion space, robot positioning time, air piping and signal wiring, and engineering-design notes for robot hands.

Chapter 4 Specifications of the Robot Controller
Lists the specifications of the robot controller and controller setting table (SETPRM LIST).

Chapter 5 Warranty
Describes the warranty period and coverage.

Appendix How to Use the Manual Pack CD

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 space which can be swept by the moving parts of the robot as defined by the manufacturer, plus the space which can be swept by the end-effector and the workpiece. (Quoted from the ISO 10218-1:2006.)

Restricted space: Refers to the portion of the maximum space restricted by limiting devices (i.e., mechanical stops) that establish limits which will not be exceeded. (Quoted from the ISO 10218-1:2006.)

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 that is actually used while performing all motions commanded by the task program. (Quoted from the ISO 10218-1:2006.)

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 ISO 10218-1:2006.)

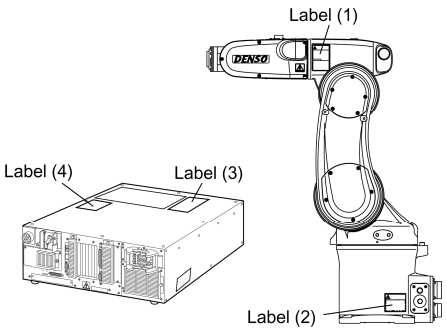
1. Introduction

This section provides safety precautions to be observed for the robot system.

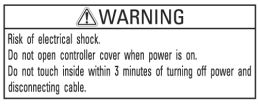
The installation shall be made by qualified personal and should confirm to all national and local codes.

2. Warning Labels

The robot unit and controller have warning labels. These labels alert the user to the danger of the areas on which they are pasted. Be sure to observe the instructions printed on those labels.



(Example: Location of labels)

Warning label	Instructions printed on the label
 Label (1)	Risk of injury. Never enter the restricted space.
<Except HM>  <HM>  Label (2)	<u>For UL-Listed robot units only</u> Risk of injury. This label alerts the user that pressing the brake release switch could drop the arm.
 Label (3)	Risk of electrical shock. Never open the controller cover when the power is on. Never touch the inside of the controller for at least 3 minutes even after turning the power off and disconnecting the power cable.
 Label (4)	Risk of injury. Be sure to perform lockout/tagout before starting servicing. Turning the power ON when a person is inside the safety fence may move the arm, causing injuries.

3. Installation Precautions

3.1 Insuring the proper installation environment

■ **For standard type and cleanroom type**

The standard and cleanroom types have 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 material,

(4) there is a mist,

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

■ **For dust- & splash-proof type**

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

(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.

3.2 Service space

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

3.3 Control devices outside the robot's restricted space

The robot controller, teach pendant and mini-pendant should be installed outside the robot's restricted space and in a place where you can observe all of the robot's movements and operate the robot easily.

3.4 Positioning of gauges

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

3.5 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.

3.6 Grounding resistance

The protective grounding resistance of the robot power supply should not be more than 100Ω.

3.7 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.

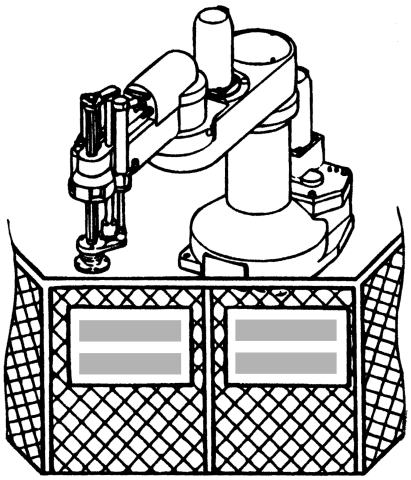
(3) Emergency stop switches should be separate from the power switch.

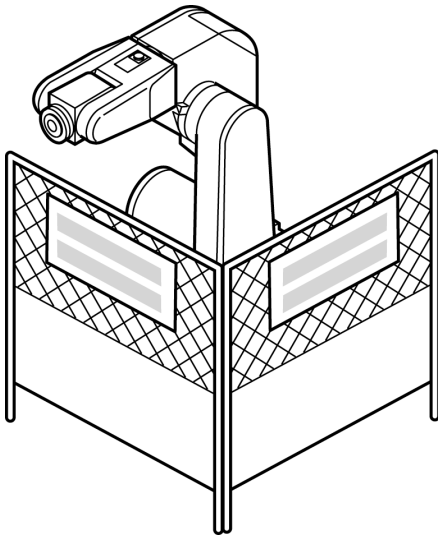
3.8 Positioning of operating status indicators

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

Note: The UL-Listed robot units have motor ON lamps on their robot arms.

3.9 Setting-up a safety fence





A safety fence should be set up so that no one can easily enter the robot's restricted space.

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

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

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

(4) The fence 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:

1) Place a door, rope or chain across the entrance/exit of the fence, 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 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, 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.

3.10 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, Chapter 2.

3.11 No robot modification allowed

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

3.12 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.

3.13 Lighting

Sufficient illumination should be assured for safe robot operation.

3.14 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.

3.15 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.

3.16 Posting the moving directions of all axes

Post a notice showing axes names and moving directions in a visible location on the robot unit. The posted moving directions should match the actual directions.

No posting or wrong direction posting may result in bodily injuries or property damages due to incorrect operation.

4. 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 4.1 and 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 4.3 "Ensuring safety of workers performing jobs within the robot's restricted space" are taken.

4.1 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 4.2 on the next page.)
2) Assuring the safety of workers performing jobs within the robot's restricted space (See Section 4.3 on the next 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".

4.2 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 operation panel or teach pendant. Take any other steps as appropriate, such as locking the cover.

4.3 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 emergency button on the teach pendant) immediately if it should be necessary to do so.

4.4 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.

4.5 Release of residual air pressure

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

4.6 Precautions for test runs

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

4.7 Precautions for automatic operation

(1) At start-up

Stay out of the safeguarded space with a safety fence when starting the robot; in particular, take extra caution in Internal automatic operation.

Before starting the robot, 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 safeguarded space (with a safety fence).
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

Stop the robot's operation by activating the emergency stop device when it is necessary to enter the safeguarded space with a safety fence to perform emergency maintenance in the case of malfunction of the robots or related equipment.

Take any necessary steps such as posting a notice on the start switch to indicate work is in progress to prevent anyone from accessing the robot.

4.8 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.

5. 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.

6. 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.

7. Safety Codes

The safety standards relating to robot systems are listed below.

As well as observing the safety precautions given in this manual, ensure compliance with all local and national safety and electrical codes for the installation and operation of the robot system.

Standards	Title
ANSI/RIA R15.06-1999	Industrial Robots and Robot Systems--Safety Requirements
ANSI/UL1740: 1998	Safety for Robots and Robotic Equipment
CAN/CSA Z434-03	Industrial Robots and Robot Systems--General Safety Requirements
ISO10218-1: 2006	Robots for industrial environments--Safety requirements--Part 1: Robot
NFPA 79: 2002	Electrical Standard for Industrial Machinery

8. Battery Recycling

DENSO Robot uses lithium batteries.

Discard batteries according to your local and national recycling law.

廢電池請回收

EU

Contents

Chapter 1 Packing List of the Robot

1.1 Standard Components

The components listed below are contained in the product package.

Standard Components

No.	Item	Q'ty
(1)	Robot unit	1
(2)	Robot controller	1
(3)	Power cable (5 m)	1
(4)	Motor & encoder cable **(Note 1)** **(Option)**	1
(5)	Manuals ("Manual Pack CD" and "Safety Precautions")	1 set
(6)	NetwoRC CD (containing WINCAPSIII beta version)	1
(7)	Spare fuses for robot controller	3
(8)	Initialization floppy disk (1.44 MB format) **(Note 2)**	1
(9)	Pendantless connector (Dummy connector)	1
(10)	Connector set for hand control signals (for CN20 and CN21)	1 set
(11)	Direction indicator label **(Note 3)**	1
(12)	Warning label **(Note 4)**	1
(13)	Spare output IC for robot controller	1
(14)	Dowel pins (internally threaded positioning pin and diamond-shaped pin)	1 set
(15)	Short sockets for robot controller	2

Note 1: Choose a motor & encoder cable from the table below. The 20-m motor & encoder cable (standard/splash-proof) is not available for controllers equipped with extended-joint options or UL-Listed robot units. The internal cable bending radius shall at least be 200 mm. Excessively bending will result in broken lead wires.

Item		Part No.
Standard cable	2 m	410141-4400
Standard cable	4 m	410141-3611
Standard cable	6 m	410141-3621
Standard cable	12 m	410141-3631
Standard cable	20 m	410141-4440

Note 2: Preserve the initialization floppy disk in a safe place. The disk contains CALSET-related arm data exclusively prepared for your robot. If a memory error appears on the teach pendant due to a memory failure, use the disk to load the arm data to the robot controller. (Refer to the INSTALLATION & MAINTENANCE GUIDE, "Using the Initialization Floppy Disk.")

Note 3: After installation, attach the direction indicator label in a position on the robot unit that can be easily seen.

Note 4: Attach the warning label on the robot safety fence or other location where workers will easily notice it. If necessary, prepare a plate for attaching the seal.

1.2 Optional Components

The table below lists the optional components.

Optional Components

Classification	No.	Item		Remarks		Part No.
I/O cables	1	Standard I/O cable set		(8 m) Incl. Nos. 1-1 and 1-2.		410149-0940
				(15 m) Incl. Nos. 1-1 and 1-2.		410149-0950
	1-1	I/O cable for “Mini I/O” (68pins)		(8 m)		410141-2700
				(15 m)		410141-2710
	1-2	I/O cable for “HAND I/O”		(8 m)		410141-1740
				(15 m)		410141-1750
	2	I/O cable for “Parallel I/O board” (96 pins)		(8 m)		410141-3050
				(15 m)		410141-3060
	3	I/O cable for “SAFETY I/O” (36 pins) (Only for global type)		(8 m)		410141-3580
				(15 m)		410141-3590
Operation devices	4	Teach pendant		(4 m) With cable		410100-1570
				(8 m) With cable		410100-1580
				(12 m) With cable		410100-1590
	5	Mini-pendant kit (Incl. cable and WINCAPSIII Light)		(4 m)	Japanese indication	410109-0390
					English indication	410109-0400
				(8 m)	Japanese indication	410109-0410
					English indication	410109-0420
				(12 m)	Japanese indication	410109-0430
					English indication	410109-0440
	6	Pendant extension cable		(4 m)	For TP, MP	410141-3710
				(8 m)	For TP, MP	410141-3720
Programming support tool	7	WINCAPSIII		CD-ROM (common to the languages--Japanese, English, German, Korean, and Chinese)		410090-0980
Optional boards for the robot controller	8	Parallel I/O board	Shipped as installed on the controller	NPN		410010-3320
				PNP		410010-3330
			Shipped as individual boards (supply part)	NPN		410010-3340
				PNP		410010-3350
	9	DeviceNet board	Shipped as installed on the controller	For Slave station		410010-3370
				For Master station		410010-3380
				For Master & slave station		410010-3390
			Shipped as individual boards (supply part)	For Slave station		410010-3400
				For Master station		410010-3410
				For Master & slave station		410010-3480
	10	CC-Link board		Shipped as installed on the controller		410010-3430
				Shipped as individual boards (supply part)		410010-3440
	11	Conveyor tracking board		Shipped as installed on the controller		410010-3460
				Shipped as individual boards (supply part)		410010-3470

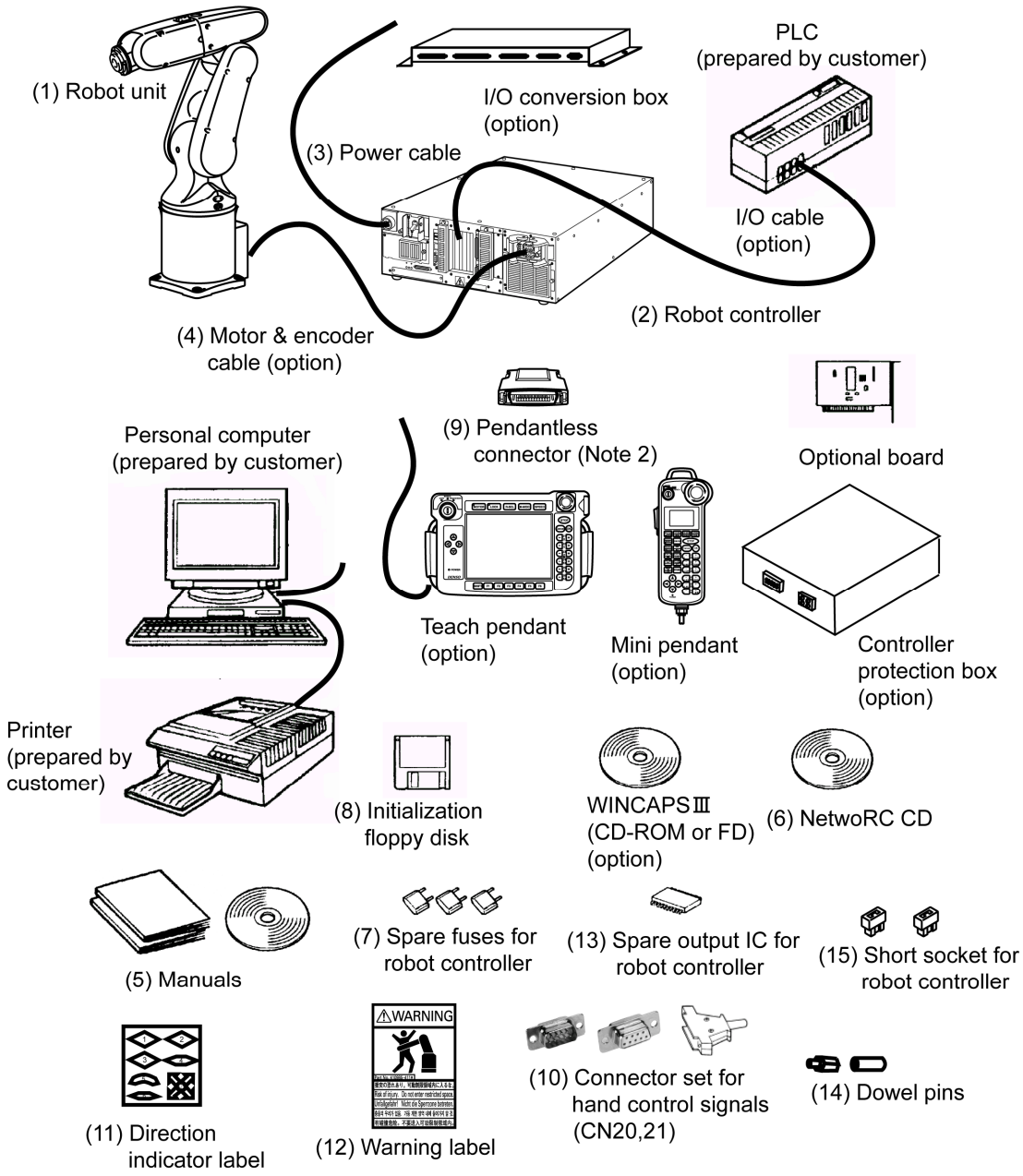
Optional Components

Classification	No.	Item	Remarks	Part No.
Optional functions (For own optional board etc.)	12	Optional function for RS232C board Board manufacturer: CONTEC CO., LTD. Model: COM-2P(PCI)H	Shipped after integrated in the controller	410006-0260
			Added when the board is purchased as a spare part	410006-0270
	13	Optional function for S-LINK V board Board manufacturer: SUNX CO., LTD Model: SL-VPCI	Shipped after integrated in the controller	410006-0280
			Added when the board is purchased as a spare part	410006-0290
	14	Optional function for PROFIBUS-DP slave board Board manufacturer: Hilscher GmbH Model: CIF50-DPS\DENSO	Shipped after integrated in the controller	410006-0300
			Added when the board is purchased as a spare part	410006-0310
	15	EtherNet/IP function Board manufacturer: Hilscher GmbH Model: CIFX 50-RE\DENSO	Shipped after integrated in the controller	410006-0800
			Added when the board is purchased as a spare part	410006-0810
	16	Optional function for memory extension	Extension only upon controller shipment (3.25MB to 5.5MB)	410006-0320
Optional box	17	Controller protection box		410181-0090
	18	I/O conversion box	For interchangeability with RC5 type controller	410181-0100
CD manuals	19	Manual Pack CD	Contained in the robot package.	410002-2661
Optional manuals (Printed materials, English edition)	20	Instruction manual for VP-G, full set	Includes No. C and No. D	410009-0320
	C	Instruction manual for VP-G, basic set	Includes No. C-1 to No. C-3	410009-0220
	C-1	GENERAL INFORMATION ABOUT ROBOT	For VP-G	410002-2530
	C-2	RC7M CONTROLLER MANUAL	For RC7M controller	410002-2430
	C-3	ERROR CODE TABLES		410002-3370
	D	Instruction manual for VP-G, extension set	Includes No. D-1 to No. D-7	410009-0100
	D-1	INSTALLATION & MAINTENANCE GUIDE	For VP-G	410002-2550
	D-2	STARTUP HANDBOOK		410002-2750
	D-3	SETTING-UP MANUAL		410002-3310
	D-4	PROGRAMMER'S MANUAL (I)		410002-3330
	D-5	PROGRAMMER'S MANUAL (II)		410002-3350
	D-6	Panel Designer USER'S MANUAL		410002-6480
	D-7	OPTIONS MANUAL	For RC7M controller	410002-2650

Chapter 2 Configuration of the Robot System

2.1 Configurators

The figure below shows configurators of the typical robot system.



Note 1: Items (1) to (15) are the standard components listed on page 1.

Note 2: The pendantless connector should be attached to the robot controller when no teach pendant or mini-pendant is connected.

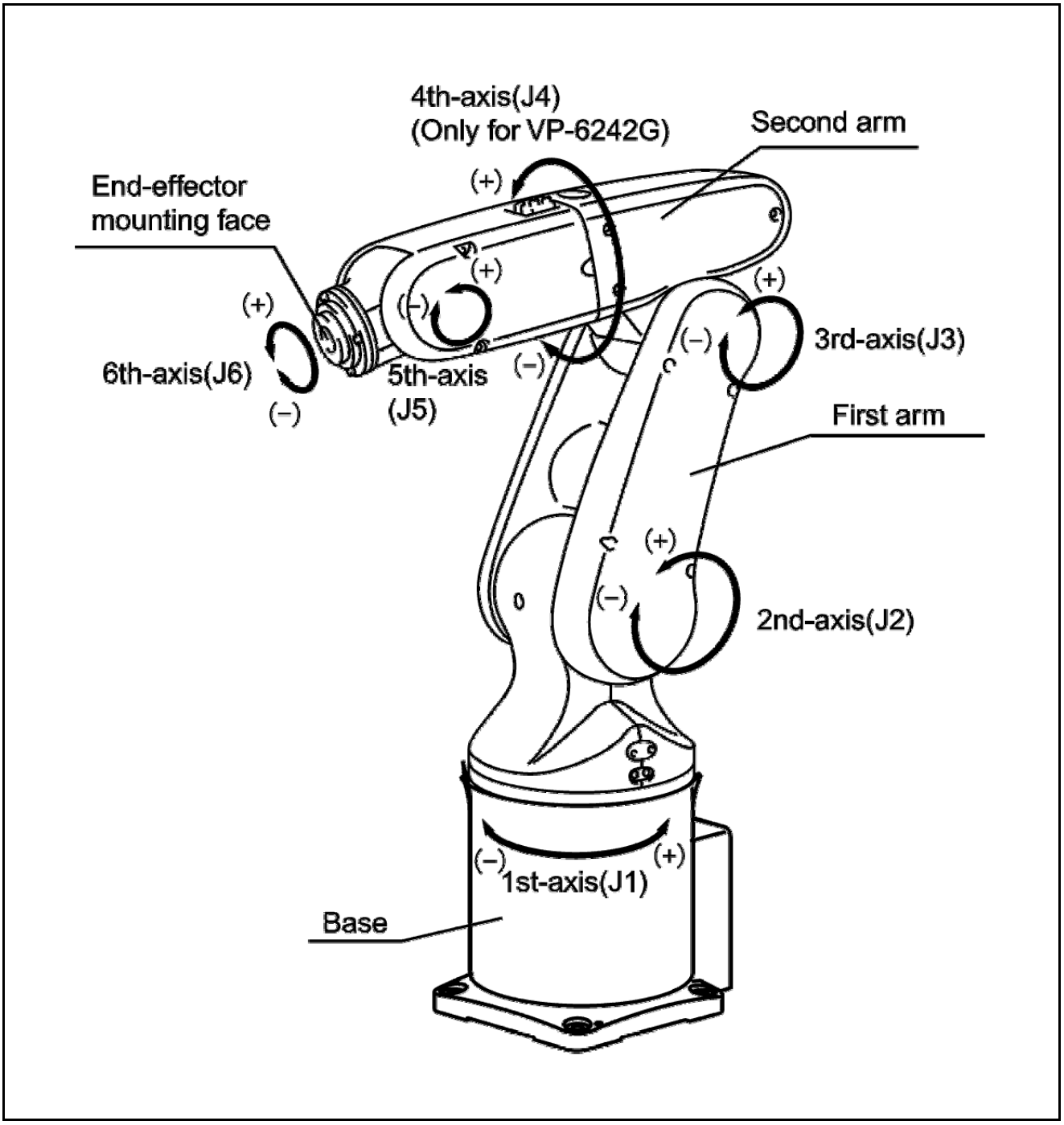
Note 3: The components illustrated above are typical models or parts.

Configurators of the Robot System (VP-G series)

2.2 Names of Robot Unit Components

2.2.1 Robot Unit Components and Rotation Direction

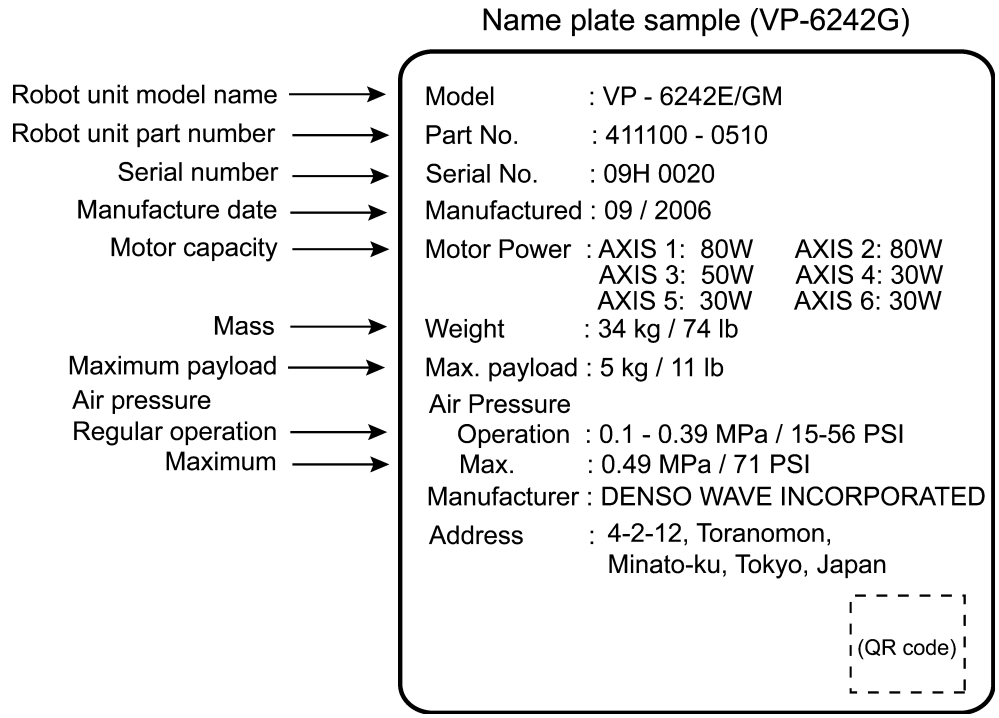
The figure below shows the names of the components of the robot unit and the rotation direction of each axis.



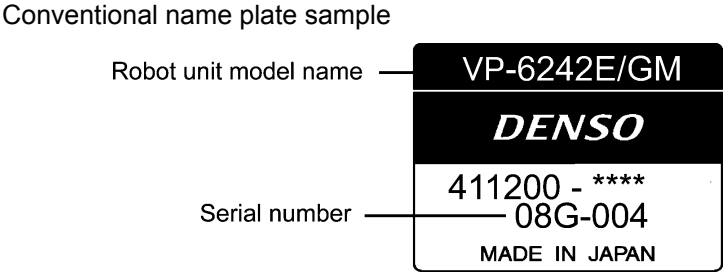
Names of Components (VP-G series)

2.2.2 Name Plate

The robot unit has a name plate pasted on the base. The serial number printed on the name plate, which is the same as that printed on the controller's name label, identifies an individual robot.



Note: The design of the name plate has changed to the one shown above in 2006. The conventional name plate is as shown below.



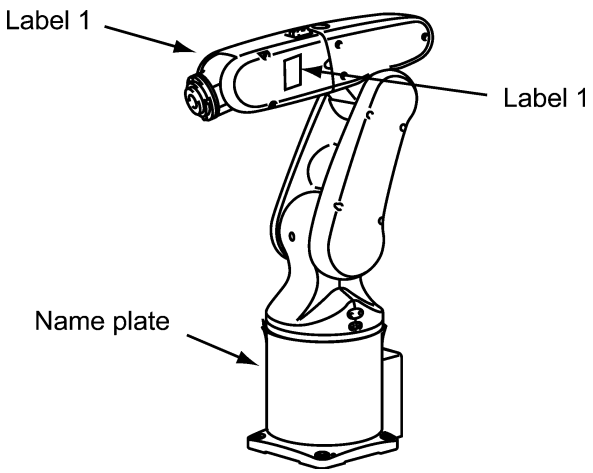
Name Plate Sample (VP-G series)

2.2.3 Warning and Caution Labels

The robot unit has warning and caution labels pasted as shown below. They alert the user to the dangers of the areas on which they are pasted. Be sure to observe the instructions printed on those labels.

Warning and Caution Labels on the Robot Unit

Location of labels

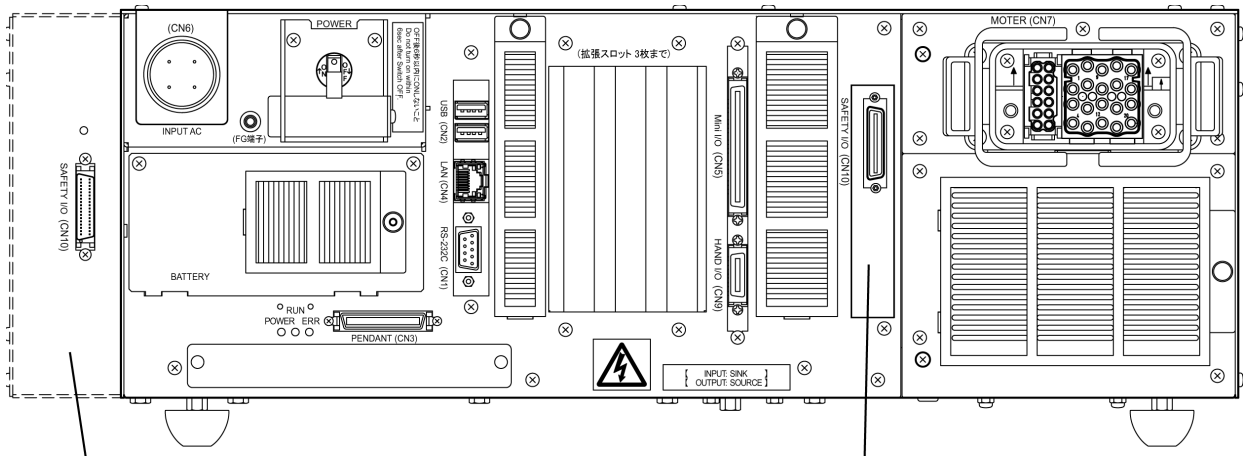


Warning and caution labels on the robot unit	Additional description
Label 1  	Contact with the robot unit which is in motion can cause serious injuries. Observe the following: (1) Never enter the robot's restricted space when the robot is in motion or the motor power is on. (2) When you need to enter the robot's restricted space for recovery from robot failures, be sure to cut the power to the robot motors by activating an emergency stop device or the like.

2.3 Names of the Robot Controller Components

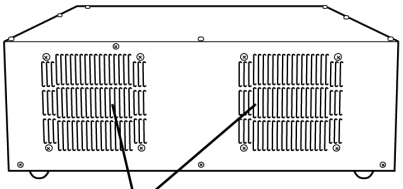
The figure below shows the names of the robot controller components.

Note: For warning and caution labels pasted on the controller, refer to the RC7M CONTROLLER MANUAL.

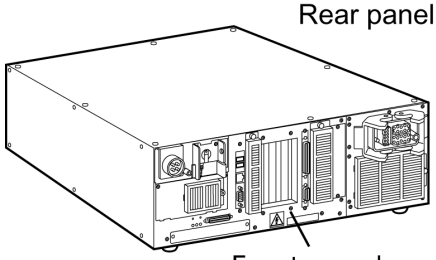


SAFETY BOX
(Only for global type with safety box)

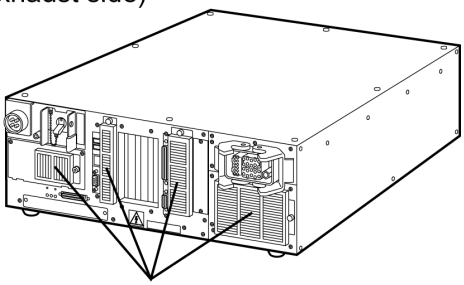
SAFETY BOARD
(Only for global type with safety board)



Rear panel (Air exhaust side)



Front panel



Air intake filters

Connectors for the VP-G series (Encoders connected via bus)

Connector No.	Marking	Name
CN1	RS-232C	Serial interface connector
CN2	USB	USB connector (2 lines)
CN3	PENDANT	Teach pendant connector
CN4	LAN	Ethernet connector
CN5	Mini I/O	I/O connector
CN6	INPUT AC	Power supply connector
CN7	MOTOR	Motor/encoder connector
CN9	HAND I/O	HAND I/O connector
CN10	SAFETY I/O	SAFETY I/O connector (Only for global type)

Names of Robot Controller Components

Chapter 3 Specifications of the Robot Unit

3.1 Robot Specifications

Following table list the robot unit specifications of the VP-G series.

VP-G Series Specifications

Item		Specifications	
		6-axis type	5-axis type **(Note 1)**
Model name of robot set **(Note 2)**		VP-6242G	VP-5243G
Model name of robot unit		VP-6242E/GM	VP-5243E/GM
Overall arm length		210 (first arm) + 210 (second arm) = 420 mm	210 (first arm) + 220 (second arm) = 430 mm
Arm offset		J3 (front arm): 75 mm	-
Maximum motion area		R = 502 mm (end-effector mounting face) R = 432 mm (Point P: J4, J5, J6 center)	R = 500 mm (end-effector mounting face) R = 430 mm (Point P: J5, J6 center)
Motion range		J1 : ±160° J2 : ±120° J3 : +160°, +19° J4 : ±160° J5 : ±120° J6 : ±360°	J1 : ±160° J2 : ±120° J3 : +136°, -128° J4 : none J5 : ±120° J6 : ±360°
Maximum payload		2 kg (2.5 kg at wrist direction downward)	2.5 kg (3 kg at wrist direction downward)
Maximum composite speed		3900 mm/s (at the center of an end-effector mounting face)	
Position repeatability **(Note 3)**		In each of X, Y and Z directions: ±0.02 mm	
Maximum allowable inertia moment		Around J4 and J5: 0.030 kgm^2 Around J6: 0.007 kgm^2	Around J5: 0.040 kgm^2 Around J6: 0.010 kgm^2
Position detection		Absolute encoder	
Drive motor and brake		AC servomotors for all joints, Brakes for all joints	
User air piping		4 systems (ϕ4x4)	
User signal line		9 (for proximity sensor signals, etc.)	
Air source	Operating pressure	1.0×10^5 Pa to 3.9×10^5 Pa	
	Maximum allowable pressure	4.9×10^5 Pa	
Degree of protection		IP30	
Airborne noise (A-weighted equivalent continuous sound pressure level)		80 dB or less	
Weight		Approx. 15 kg (32 lbs)	Approx. 13 kg (29 lbs)

Note 1: The 5-axis type robot has not the 4th axis (J4).

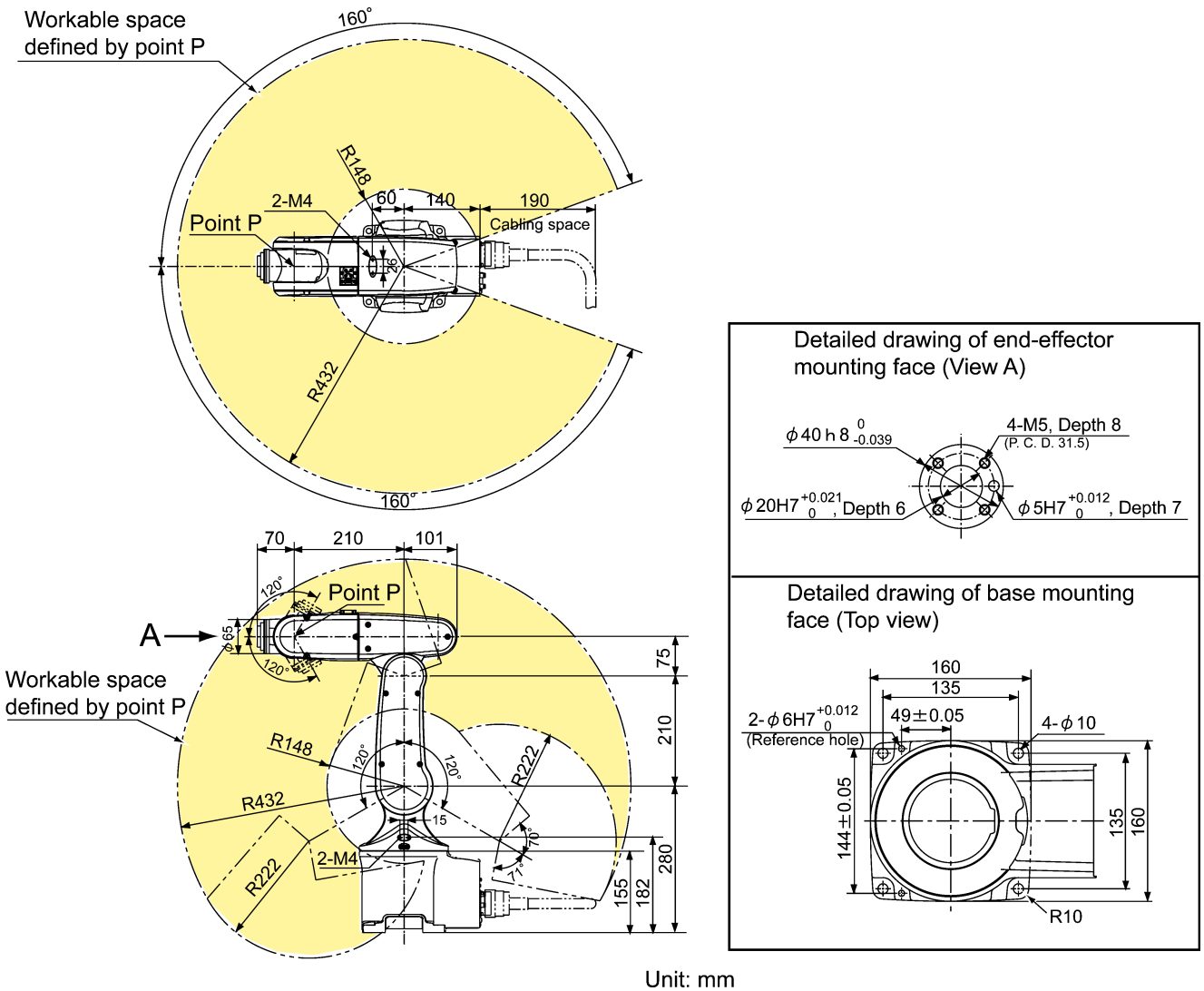
Note 2: The model name of robot set refers to the model name of a complete set including a robot unit and robot controller.

Note 3: Position repeatability is the value at constant ambient temperature.

3.2 Outer Dimensions and Workable Space of the Robot Unit

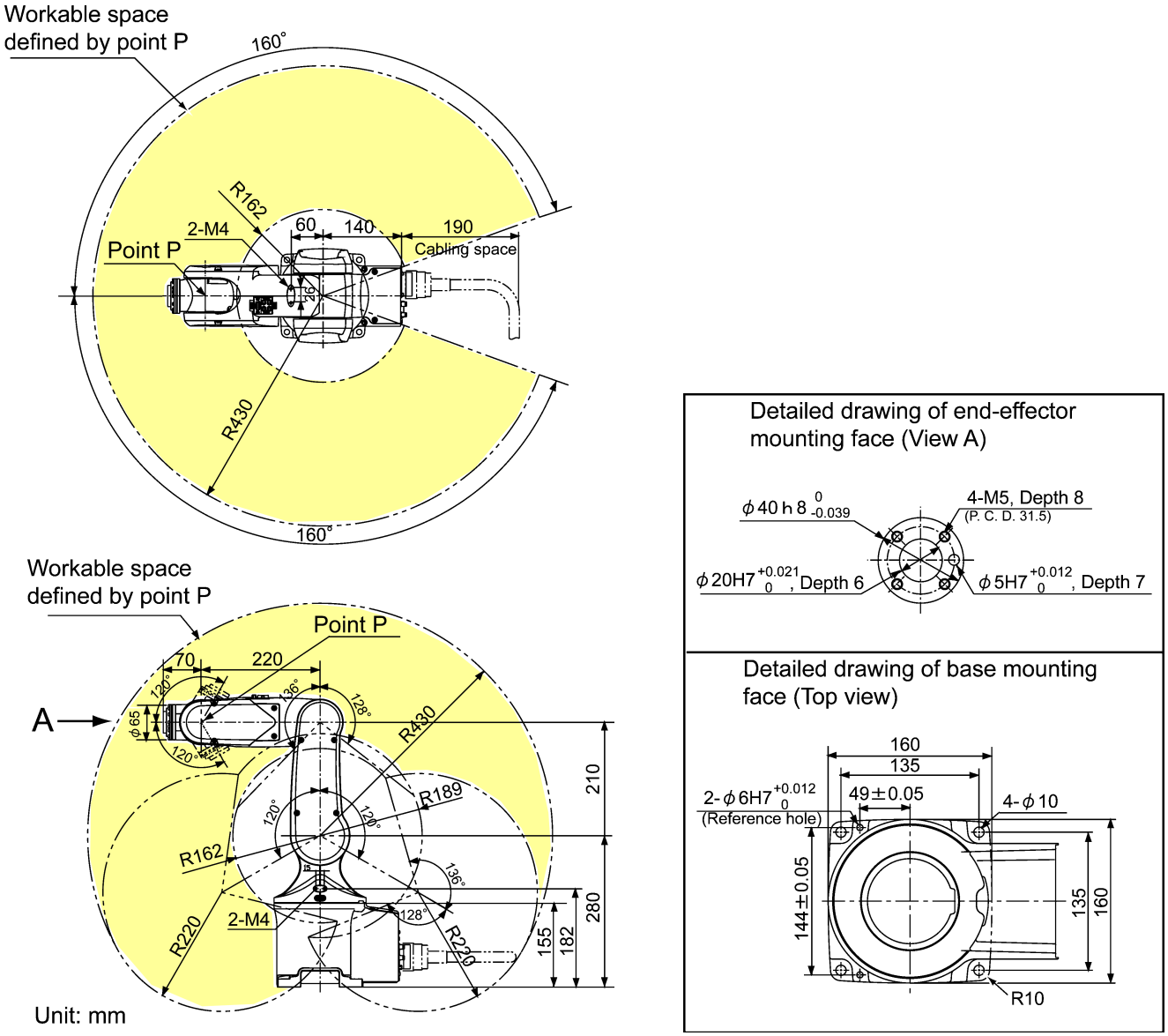
The outer dimensions and workable space of the VP-G series are shown on the following pages.

(1) VP-6242G (6-axis type)



Outer Dimensions and Workable Space [VP-6242G]

(2) VP-5243G (5-axis type)



Outer Dimensions and Workable Space [VP-5243G]

3.3 Robot Positioning Time

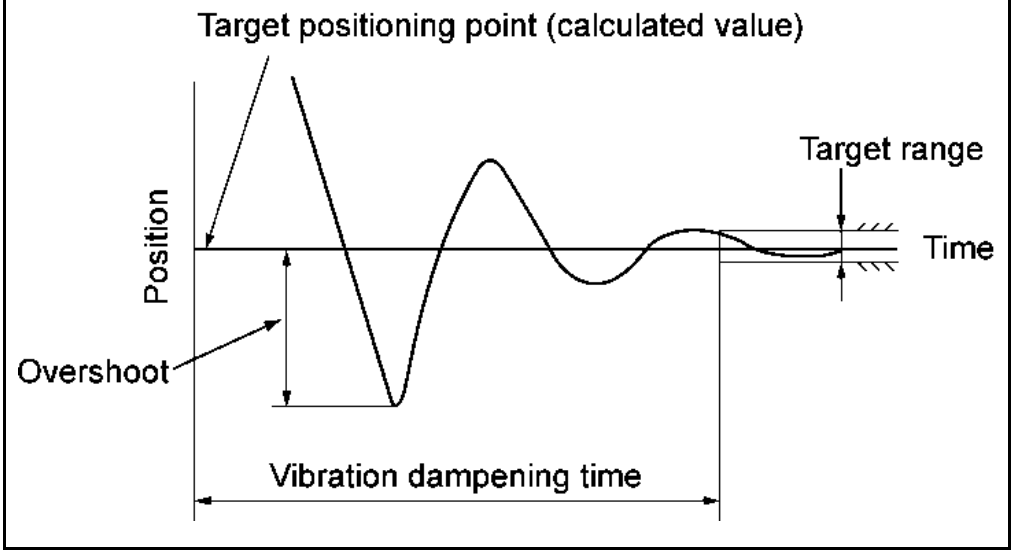
1. Positioning time means the time from the start of robot operation to the arrival at the target positioning point.
2. After the robot moves to and passes the target positioning point, vibration will be dampened and the robot positioned at the target positioning point as shown in Figure below. This vibration dampening time is not considered in the graph.

Caution (1) The vibration dampening time depends on factors such as the weight of the end-effector. If the robot is to be used in such a way that it overshoots or if the vibration damping time is of great concern, test the robot carefully beforehand.

(2) If acceleration begins before residual vibration of the robot stops, an overcurrent error (code starts from ERROR6120; the first digit represents the axis number) may be displayed. In this case, take one of the following measures:

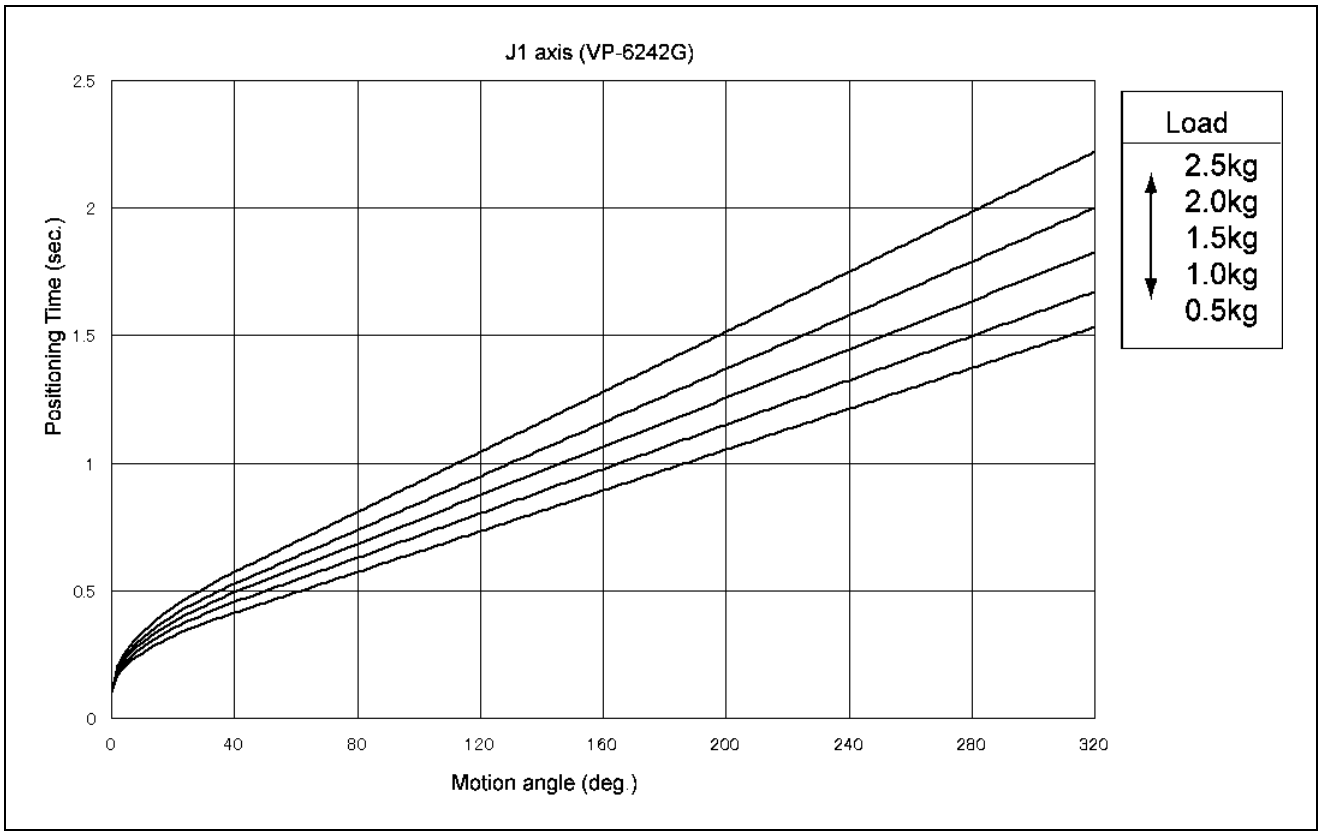
- **Lower the deceleration of the preceding operation with a DECEL command to reduce residual vibration.**
- **Keep the robot in stand-by with a DELAY command until residual vibration stops.**
- **Lower acceleration with an ACCEL command.**

(3) Operate the robot with the optimum load setting in accordance with the end-effector weight and workpiece weight. If not, a robot failure may result.

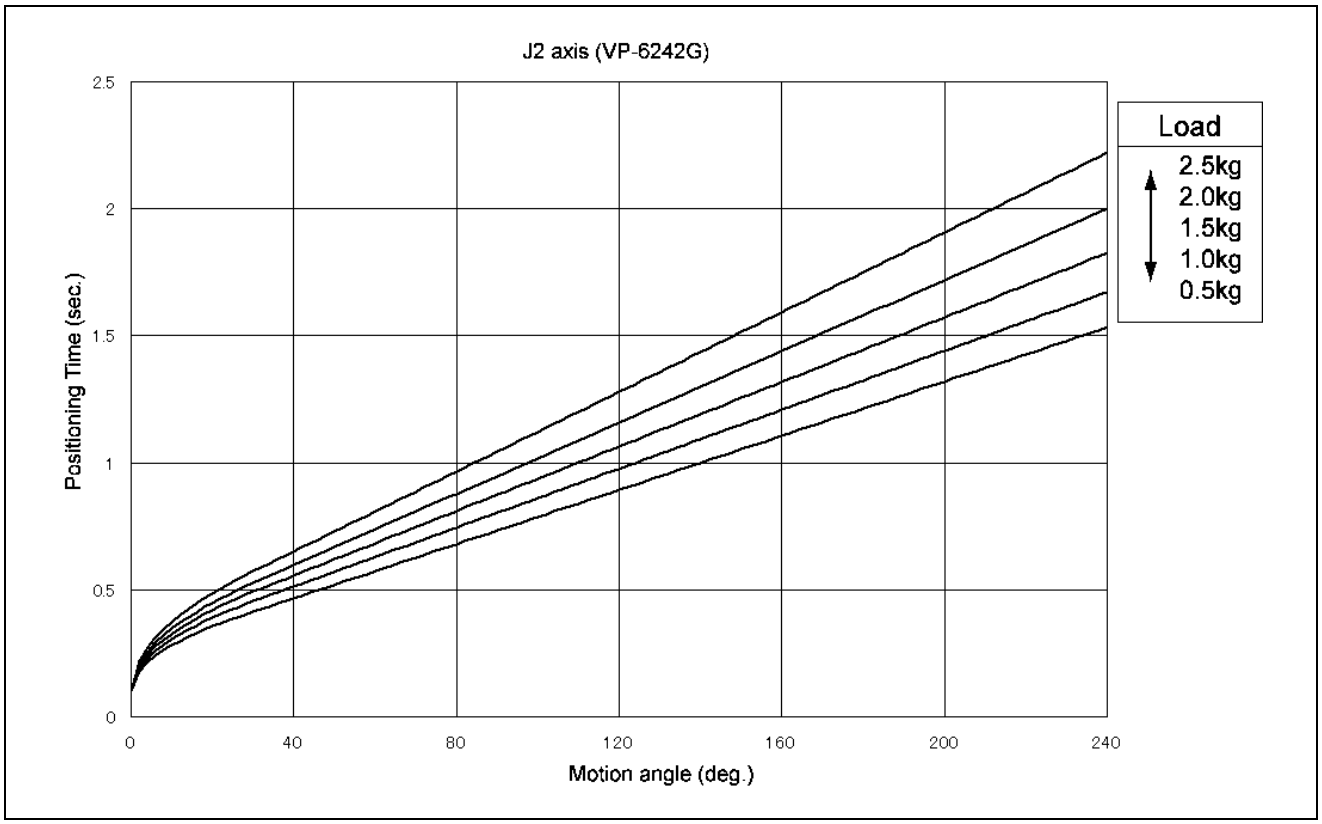


Vibration Dampening Time

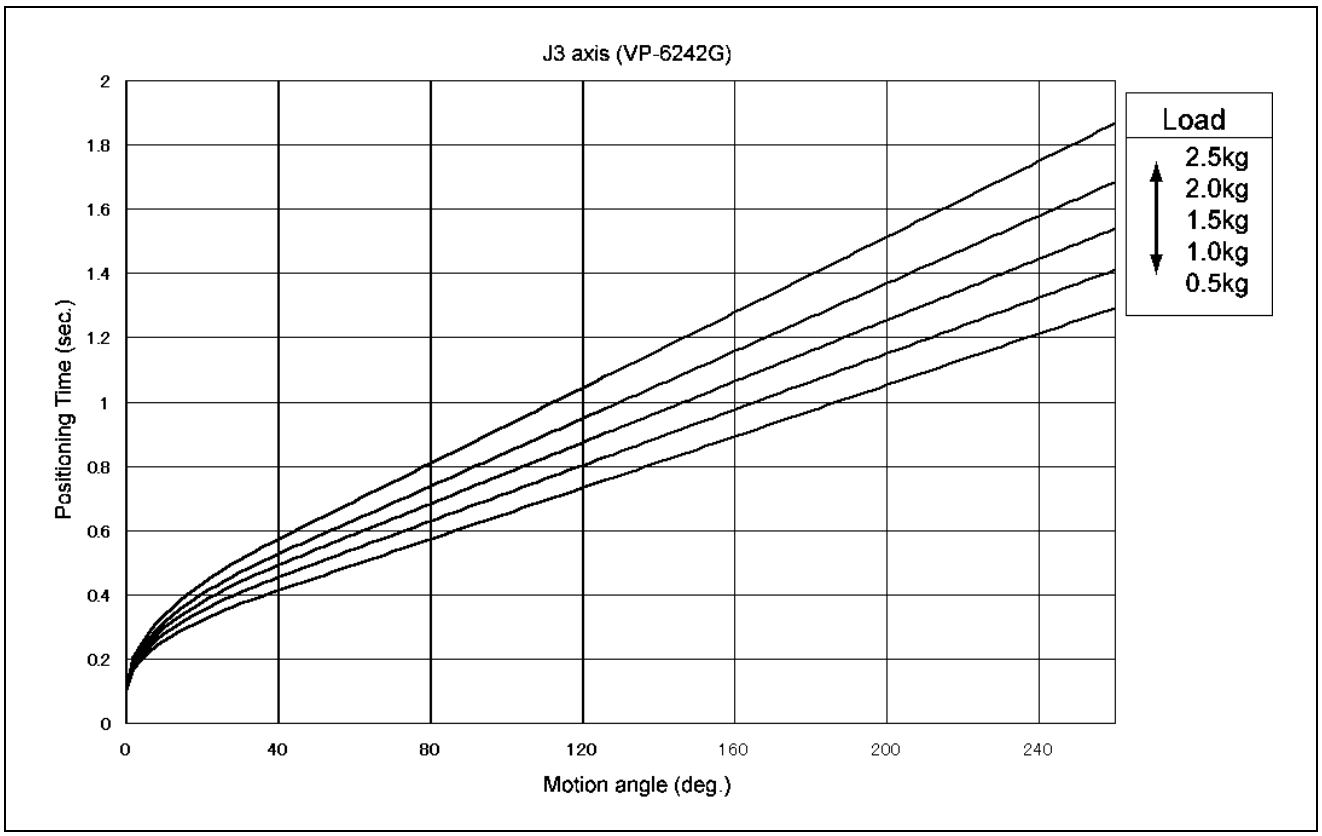
3.3.1 VP-6242G robot positioning time



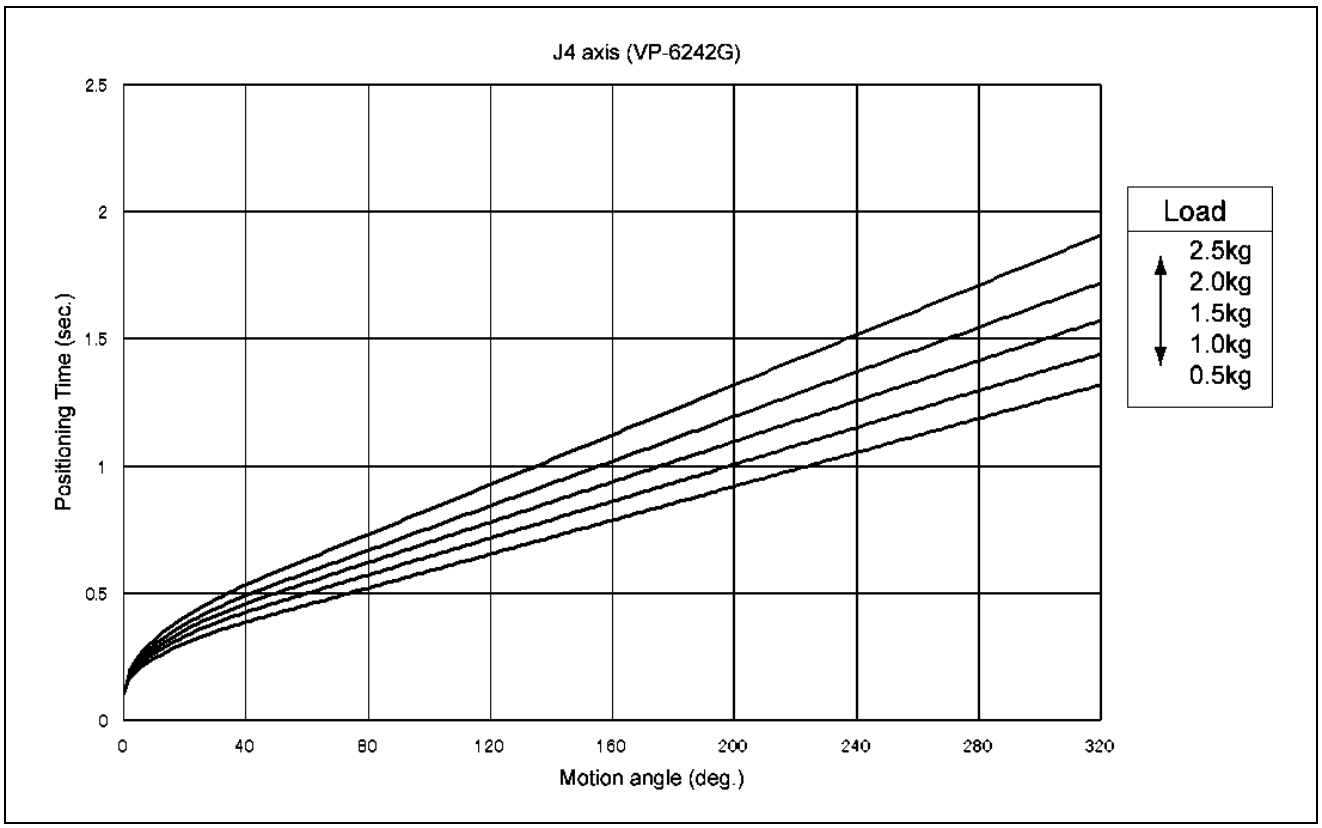
J1 Axis [VP-6242G]



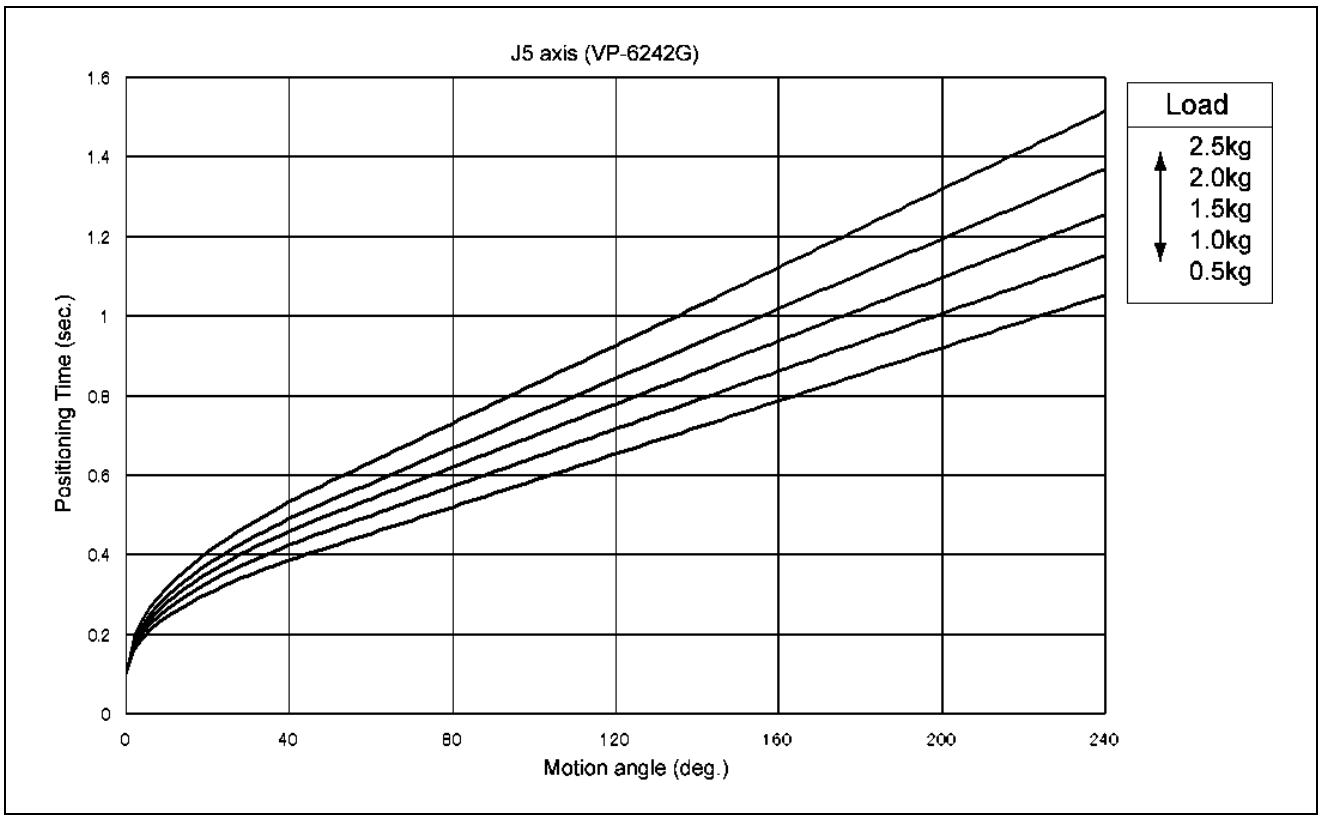
J2 Axis [VP-6242G]



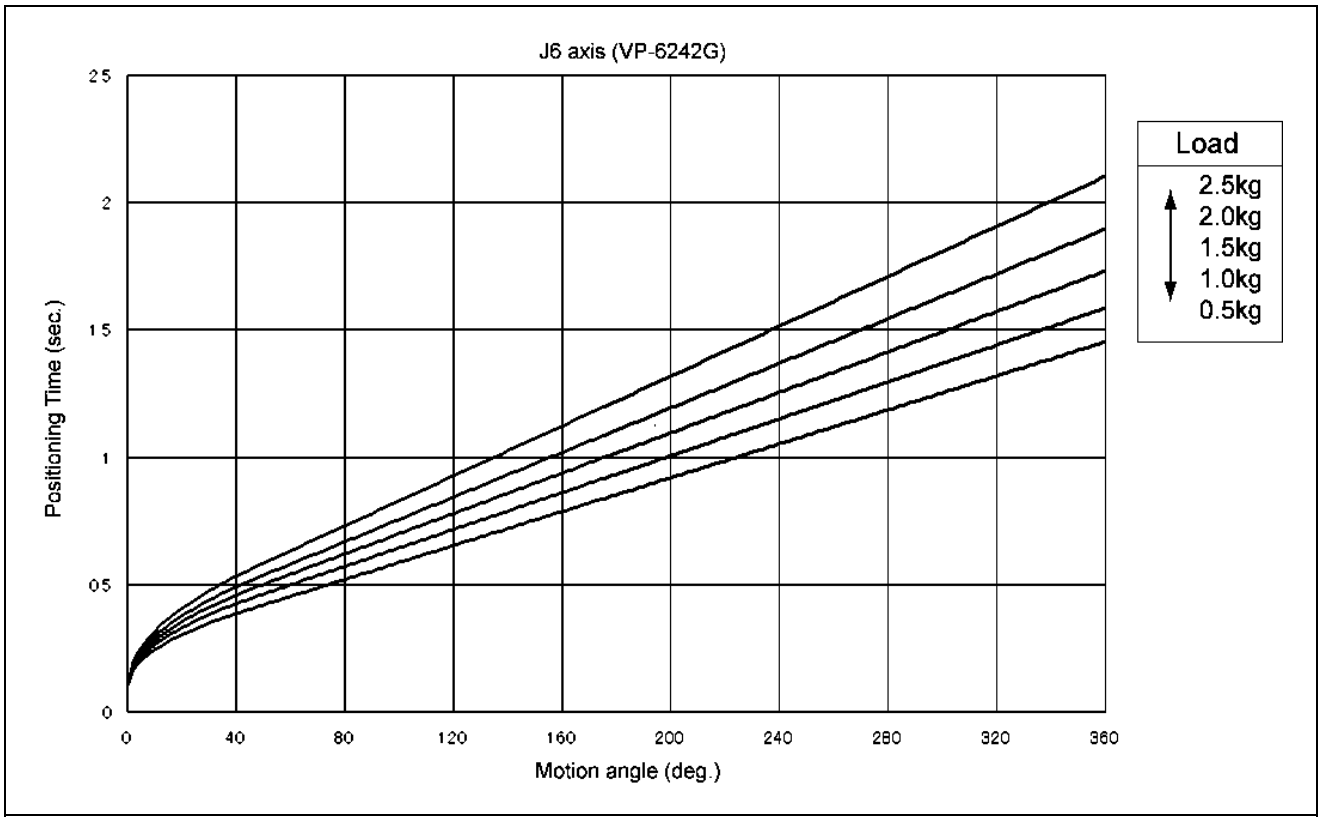
J3 Axis [VP-6242G]



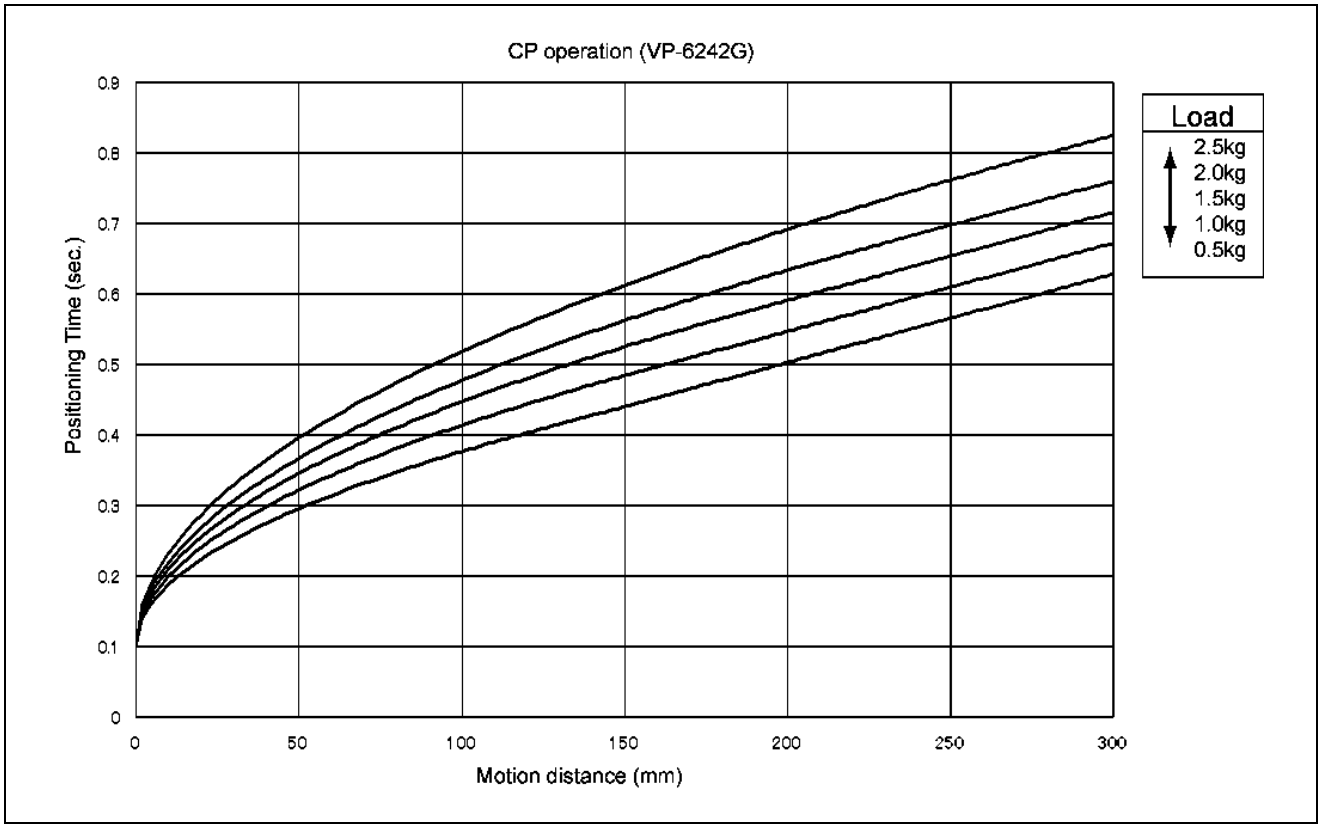
J4 Axis [VP-6242G]



J5 Axis [VP-6242G]

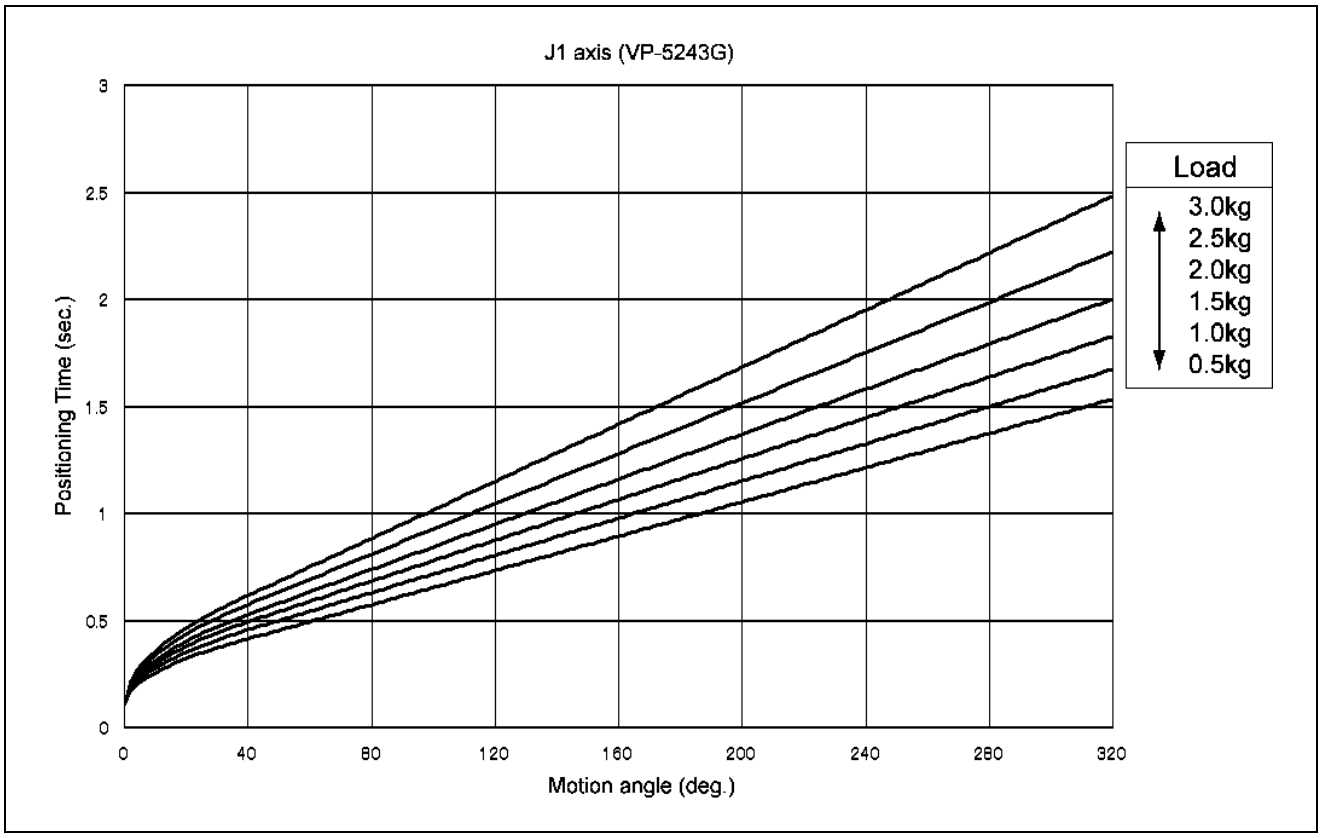


J6 Axis [VP-6242G]

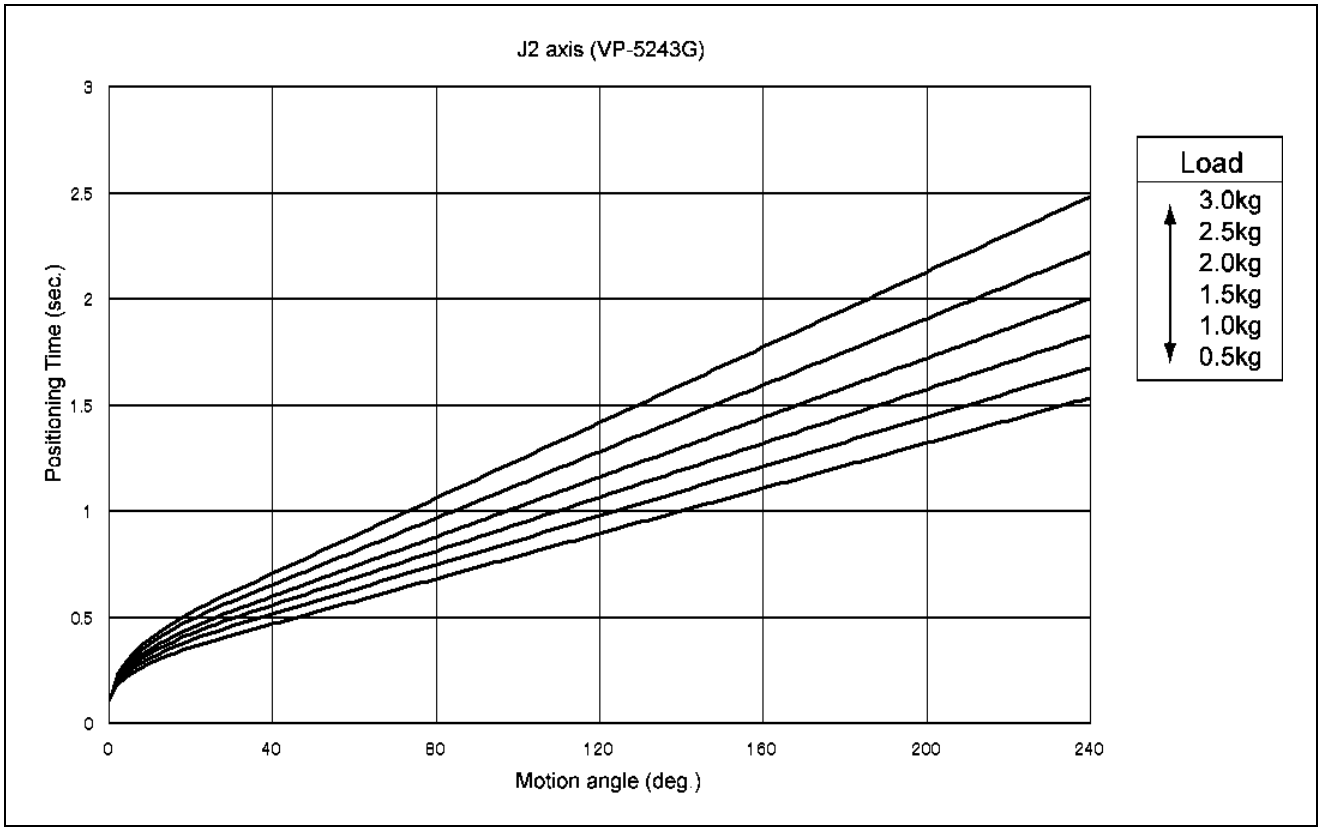


CP Operation [VP-6242G]

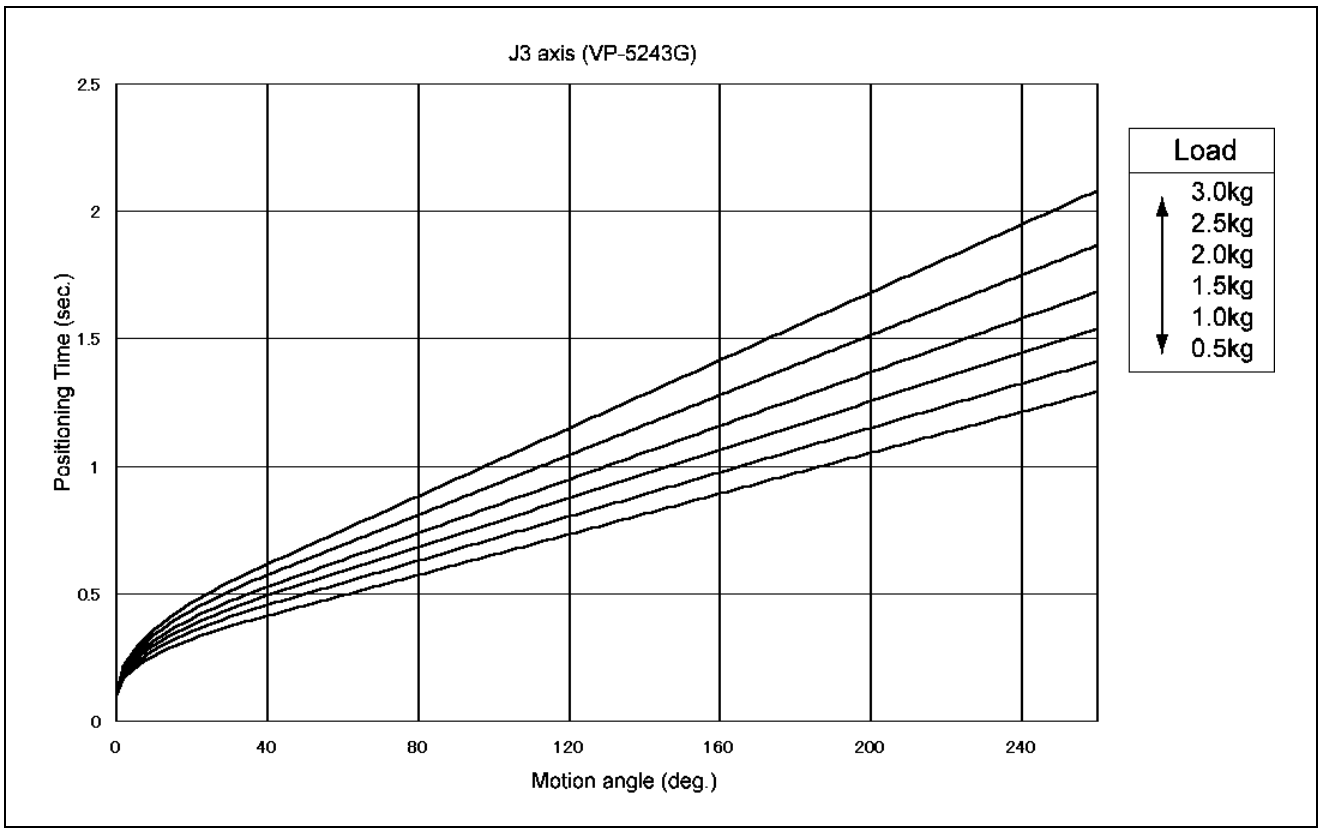
3.3.2 VP-5243G robot positioning time



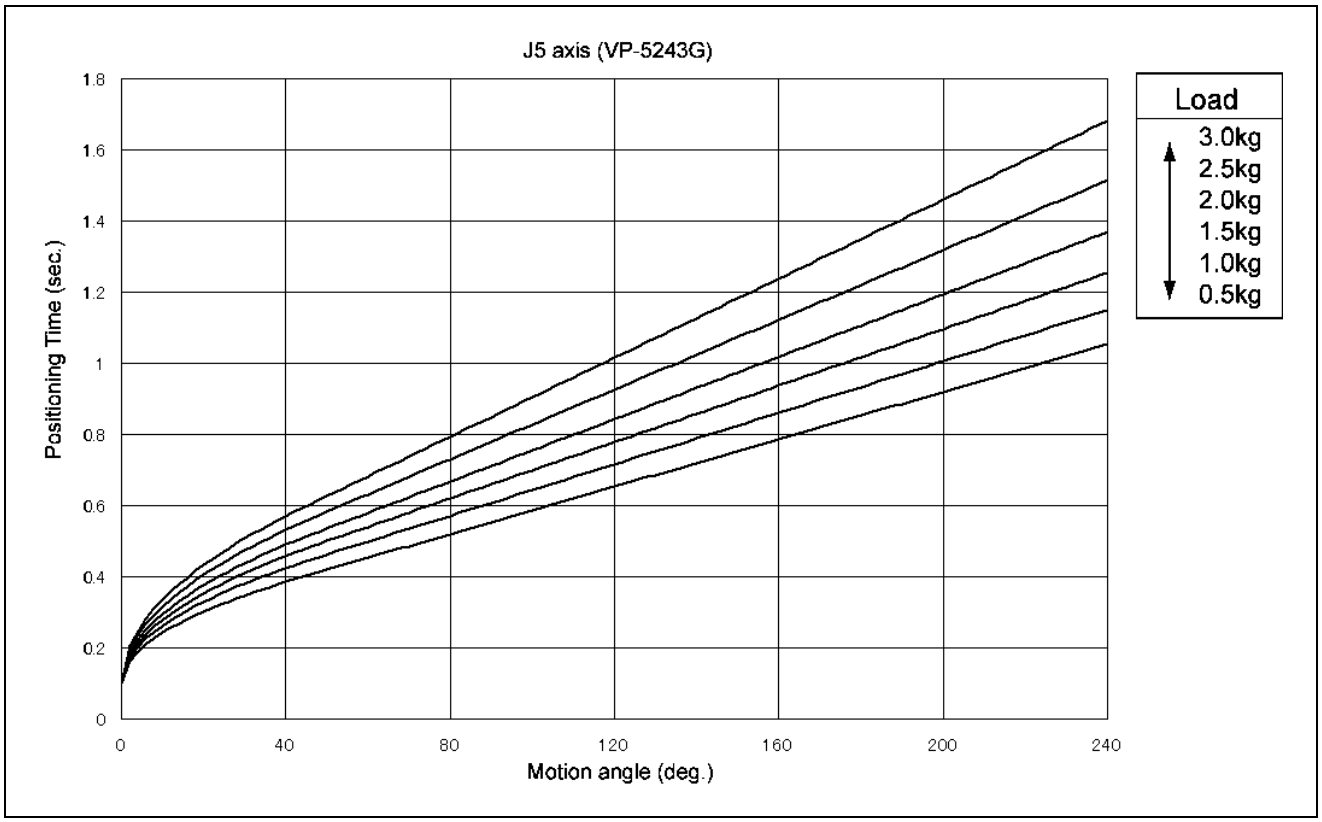
J1 Axis [VP-5243G]



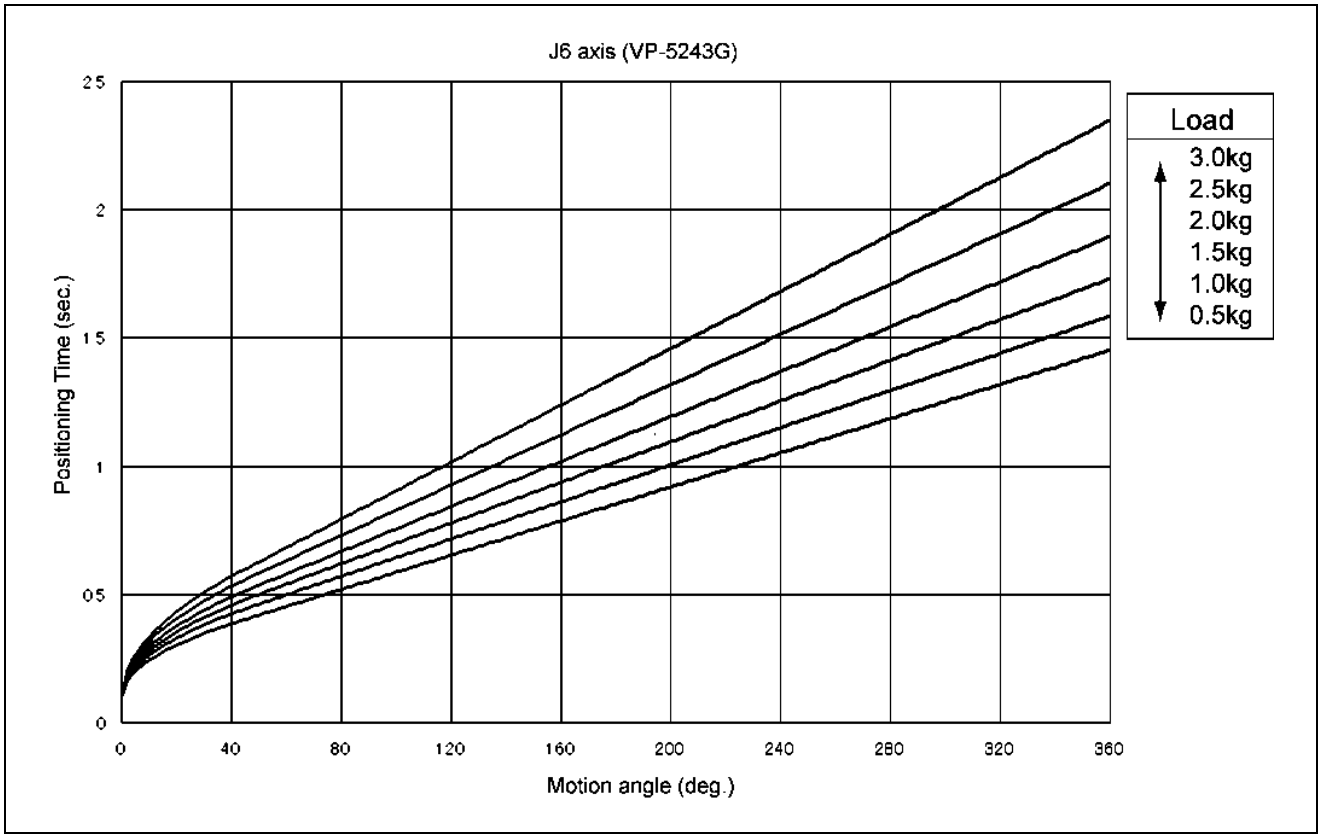
J2 Axis [VP-5243G]



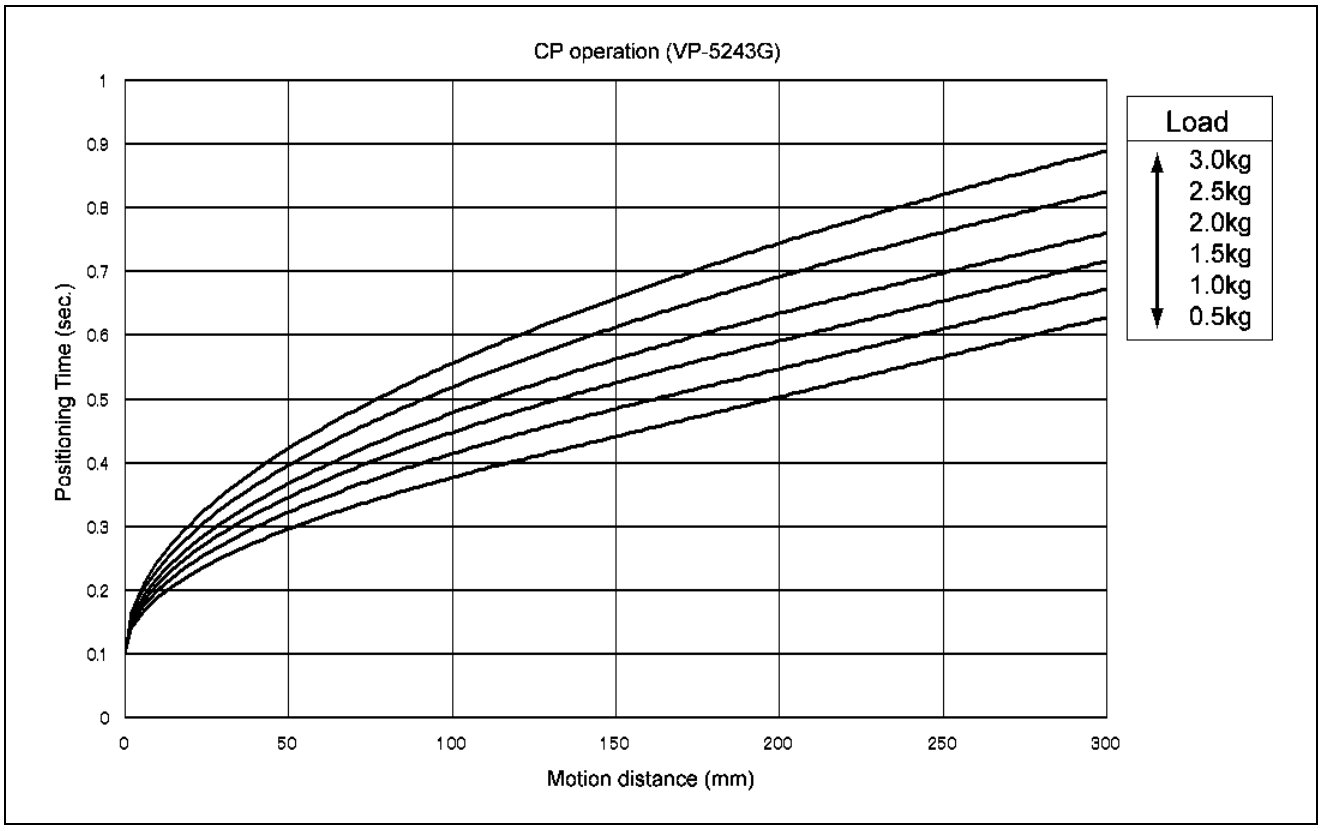
J3 Axis [VP-5243G]



J5 Axis [VP-5243G]



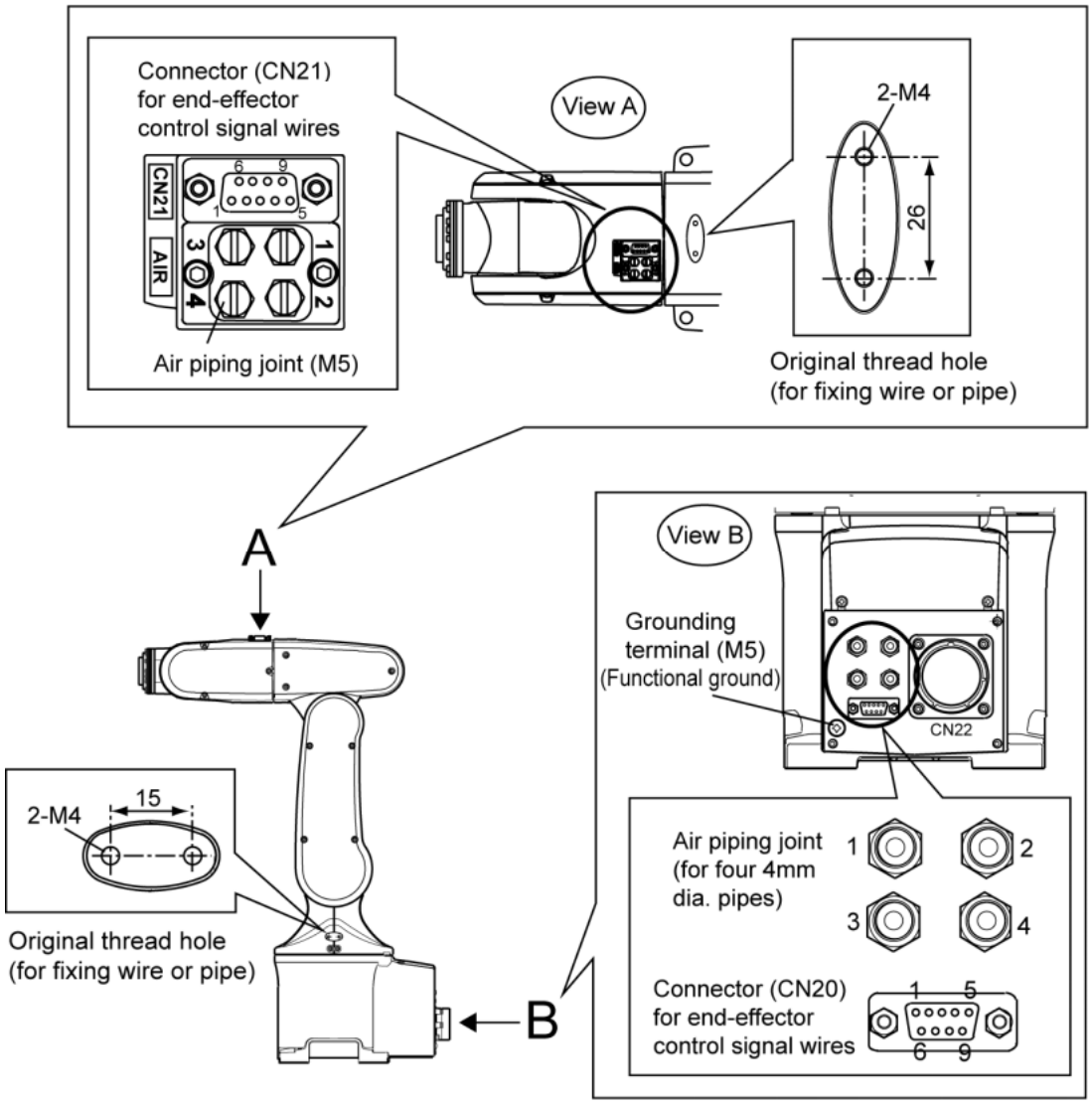
J6 Axis [VP-5243G]



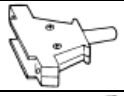
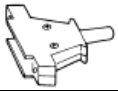
CP Operation [VP-5243G]

3.4 Air Piping and Signal Wiring

The VP-G series is equipped with 4 air pipes for air chuck and 9 signal lines. The air piping and signal wiring of the VP-G series are shown in the figure below.



Note 1: Pins #1 to #10 on CN21 and those on CN20 are connected with each other. The allowable current per line is 1 A.
Note 2: Use the attached connector sets for CN20 and CN21.

Connector set part No.	Part No.		Model and part name	Appearance
410889-0110	For CN20	410877-0570	17JE-13090-02 (D1) (Socket connector) DDK Electronics, Inc.	
		410877-0580	17JE-09H1-1B (Straight hood) DDK Electronics, Inc.	
	For CN21	410877-0560	17JE-23090-02 (D1) (Pin connector) DDK Electronics, Inc.	
		410877-0580	17JE-09H1-1B (Straight hood) DDK Electronics, Inc.	

Air Piping and Signal Wiring [VP-G series]

3.5 Precautions When Designing the End-effectors

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.**

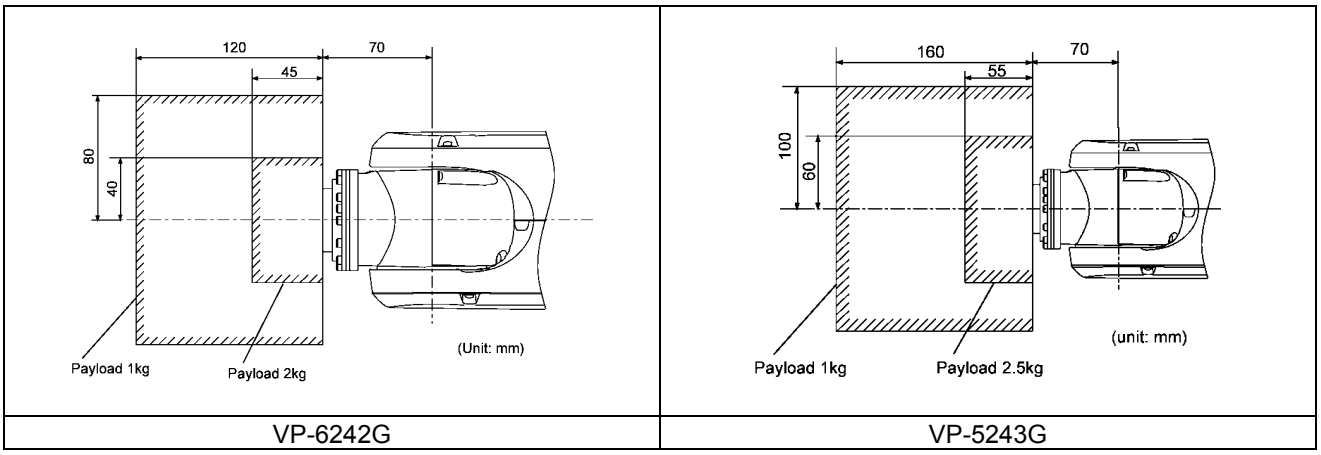
(1) Mass of end-effector

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-6242G	VP-5243G

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

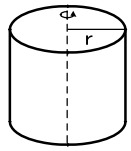
Robot model	Around axis	Maximum allowable moment
VP-6242G	Around J4 or J5	0.030kgm^2
	Around J6	0.007kgm^2
VP-5243G	Around J5	0.040kgm^2
	Around J6	0.010kgm^2

When calculating the moment of inertia around J4, J5 and J6 of the end-effector, use the formulas given in Following Table and Figure.

Moment-of-Inertia Formulas

1. Cylinder (1)

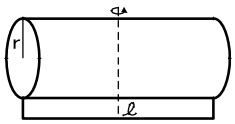
(Axis of rotation = Center axis)



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

2. Cylinder (2)

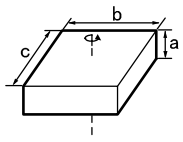
(The axis of rotation passes through the center of gravity.)



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

3. Rectangular parallelepiped

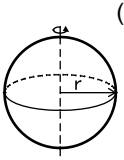
(The axis of rotation passes through the center of gravity.)



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

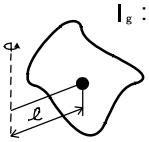
4. Sphere

(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]

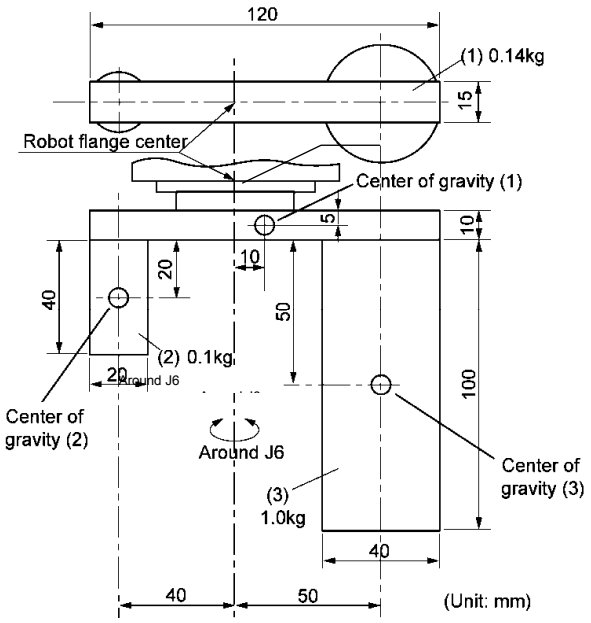
$$I = I_g + m\ell^2$$

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



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

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

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

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

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

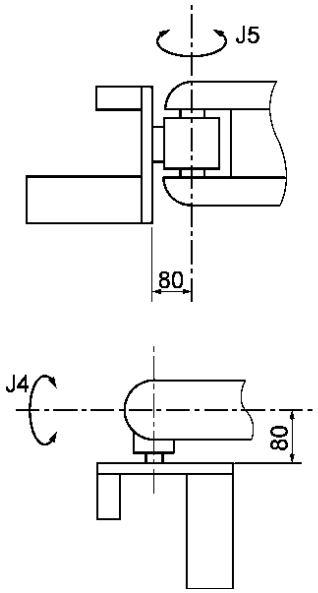
$$I_3 = \frac{1.0 \times 0.02^2}{2} + 1.0 \times 0.05^2 = 2.7 \times 10^{-3} \quad [kgm^2]$$

Moment of inertia around J6 of entire hand: I_{J6}

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

(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 above table)

$$I_1 = \frac{0.14}{12}(0.015^2 + 0.01^2) + 0.14 \times (0.08 + 0.005)^2 = 1.02 \times 10^{-3} \quad [kgm^2]$$

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

$$I_2 = \frac{0.1}{4}\left(0.01^2 + \frac{0.04^2}{3}\right) + 0.1 \times (0.08 + 0.01 + 0.02)^2 = 1.23 \times 10^{-3} \quad [kgm^2]$$

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

$$I_3 = \frac{1.0}{4}\left(0.02^2 + \frac{0.1^2}{3}\right) + 1.0 \times (0.08 + 0.01 + 0.05)^2 = 2.0 \times 10^{-2} \quad [kgm^2]$$

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

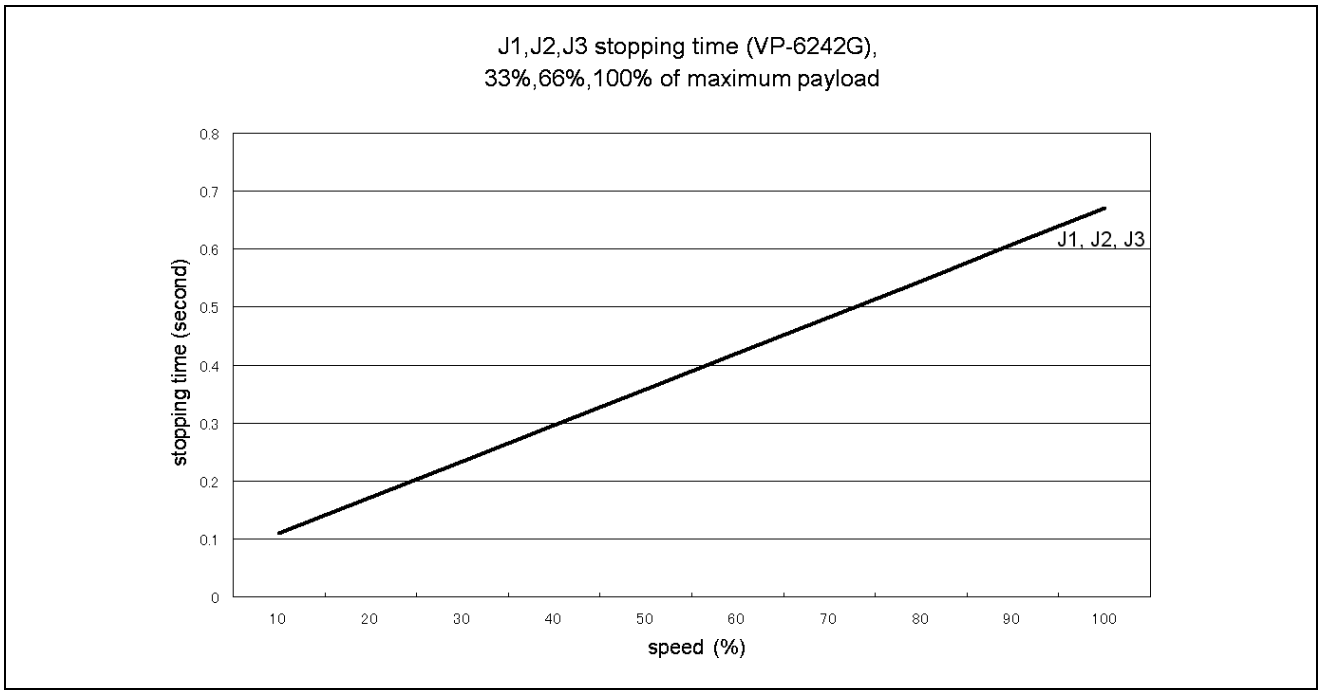
$$I_{J4} = I_{J5} = I_1 + I_2 + I_3 = 2.22 \times 10^{-2} \quad [kgm^2]$$

End-effector Moment of Inertia Calculation Example

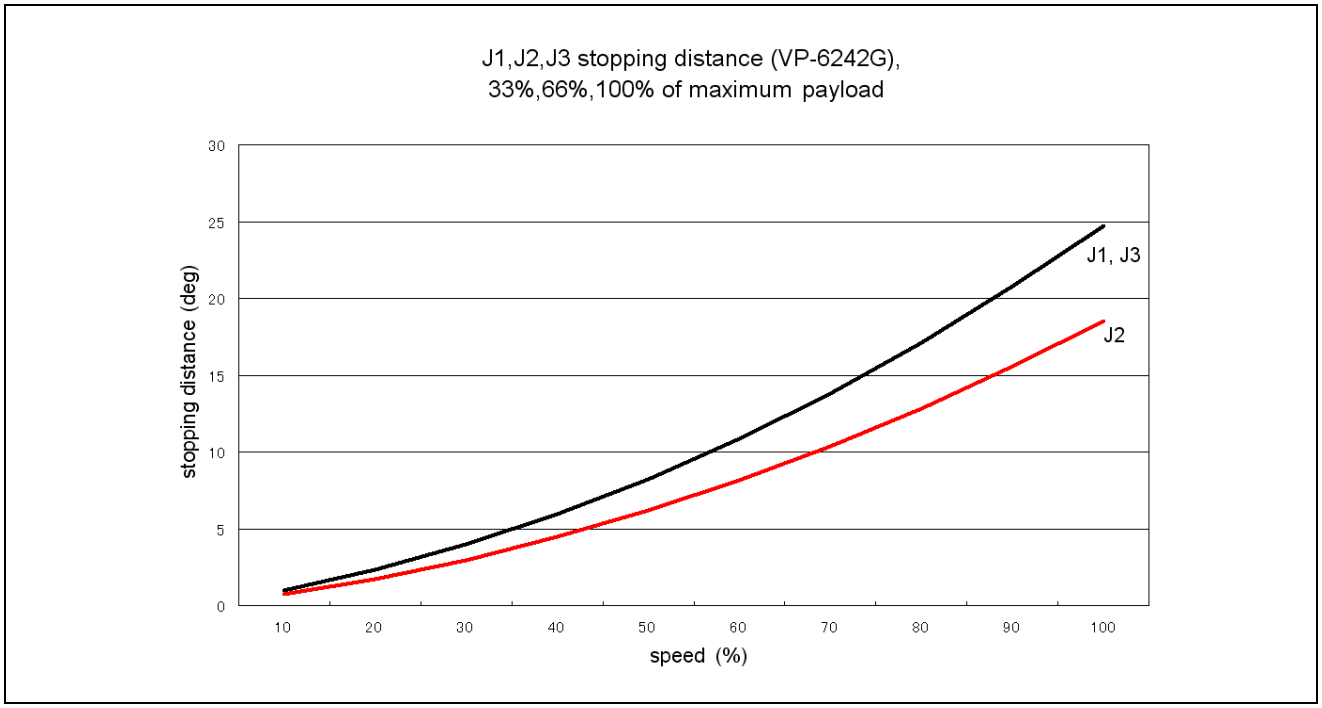
3.6 Stopping Time and Distance (Angle) at an Emergency Stop

Pressing the emergency stop button when the robot is in motion stops the robot. The stopping time required from activation of a stop signal and the distance (angle) for major three joints vary with the robot speed as shown in the graphs below. The measuring conditions are: Robot arm extended, 33%, 66% and 100% of the maximum payload.

(1) VP-6242G series

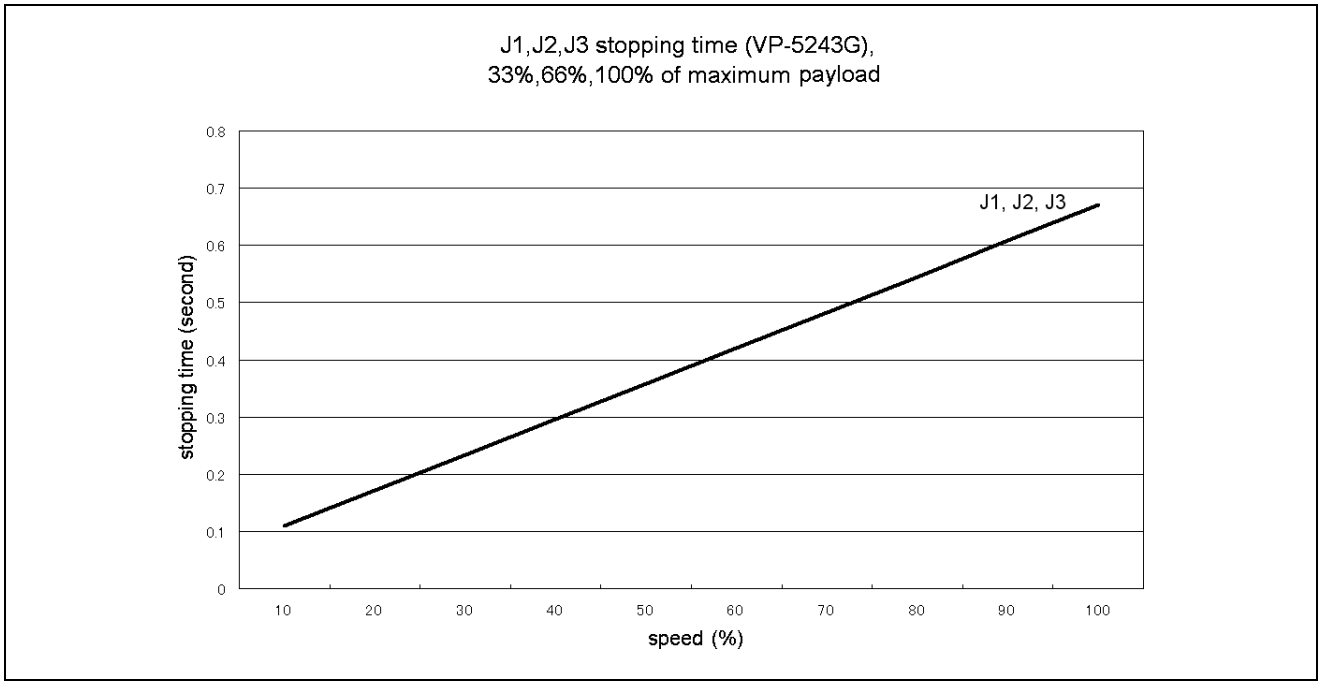


J1, J2, J3 stopping time vs. speed at an emergency stop (VP-6242G series)



J1, J2, J3 stopping distance vs. speed at an emergency stop (VP-6242G series)

(2) VP-5243G series



J1, J2, J3 stopping time vs. speed at an emergency stop (VP-5243G)

J1, J2, J3 stopping distance vs. speed at an emergency stop (VP-5243G)

Chapter 4
Specifications of the Robot Controller

4.1 Specifications

Table below lists the robot controller specifications.

RC7M Controller Specifications (1) (VP-G series)

Item			Specifications	
Applicable robot			Mini-sized, vertical articulated type VP-6242G (6-axis type)	Mini-sized, vertical articulated type VP-5243G (5-axis type)
Controller model			RC7M-VPG5/6CA*-**	RC7M-VPG5/6CA*-**
No. of controllable axes			Six axes	Five axes
Control system			PTP, CP 3-dimensional linear, 3-dimensional circular	
Drive system			All axes: Full-digital AC servo	
Language used			DENSO robot language (conforming to SLIM)	
Memory capacity			3.25 MB (equivalent to 10,000 steps, 30,000 points)	
Teaching system			1) Remote teaching 2) Numerical input (MDI)	
External signals (I/O)	Standard I/O	Mini I/O	Input signals: 8 user open points + 11 fixed system points Output signals: 8 user open points + 14 fixed system points **Note:** In global type, some fixed system points are not used.	
		HAND I/O	Input signals: 8 user open points Output signals: 8 user open points	
	SAFETY I/O (Only for Global type)		Input signals: 6 fixed system points Output signals: 5 fixed system points	
	Parallel I/O board (Option)	2 boards	Input signals: Additional 80 user open points Output signals: Additional 96 user open points	
		1 board	Input signals: Additional 40 user open points Output signals: Additional 48 user open points	
	DeviceNet board (Option)	Master & slave	Input signals: 1024 points (Master) + 256 points (Slave) Output signals: 1024 points (Master) + 256 points (Slave)	
		Master	Input signals: 1024 points Output signals: 1024 points	
		Slave	Input signals: 256 points Output signals: 256 points	
	CC-Link board (option)	Slave	Input signals: 384 points Output signals: 384 points (including remote registers RWw and RWr)	
External communication			RS-232C: 1 line Ethernet: 1 line USB: 2 lines	
Extension slot			3 (For an optional board)	
Self-diagnosis function			Overrun, servo error, memory error, input error, etc.	
Timer function			0.02 to 10 sec. (in units of 1/60 sec.)	
Error display			Error codes will be outputted on the external I/O. Error messages will be displayed in English on the teach pendant (option). Error codes will be displayed on the mini pendant (option).	
Cables	Motor & encoder cable (option)		2 m, 4 m, 6 m, 12 m, 20 m (Standard)	
	I/O cable (option)		8 m, 15 m (For Mini I/O, HAND I/O, Optional board for parallel I/O and SAFETY I/O)	
	Power cable		5 m	

RC7M Controller Specifications (2) (VP-G series)

Item	Specifications
Environmental conditions (in operation)	Temperature: 0 to 40°C Humidity: 90% RH or less (no condensation allowed)
Power source	200 VAC type: Three-phase, 200 VAC-15% to 230 VAC+10%, 50/60 Hz, 1 kVA Single-phase, 230 VAC-10% to 230 VAC+10%, 50/60 Hz, 1 kVA
	100 VAC type: Single-phase, 100 VAC-10% to 110 VAC+10%, 50/60 Hz, 1 kVA
Degree of protection	IP20
Weight	Standard type: Approx. 18 kg (40 lbs) Global type with safety board: Approx. 19 kg (42 lbs) Global type with safety box: Approx. 22 kg (49 lbs)

⚠WARNING

- **DO NOT touch fins. Their hot surfaces may cause severe burns.**
- **DO NOT insert fingers or foreign objects into openings. Doing so may cause bodily injury.**
- **Before opening the controller cover and accessing the inside of the controller for maintenance, be sure to turn off the power switch, disconnect the power cable, and wait 3 minutes or more. This is for protecting you from electric shock.**
- **DO NOT connect or disconnect connector to/from the controller while the power switch is on. Doing so may cause electric shock or controller failure.**

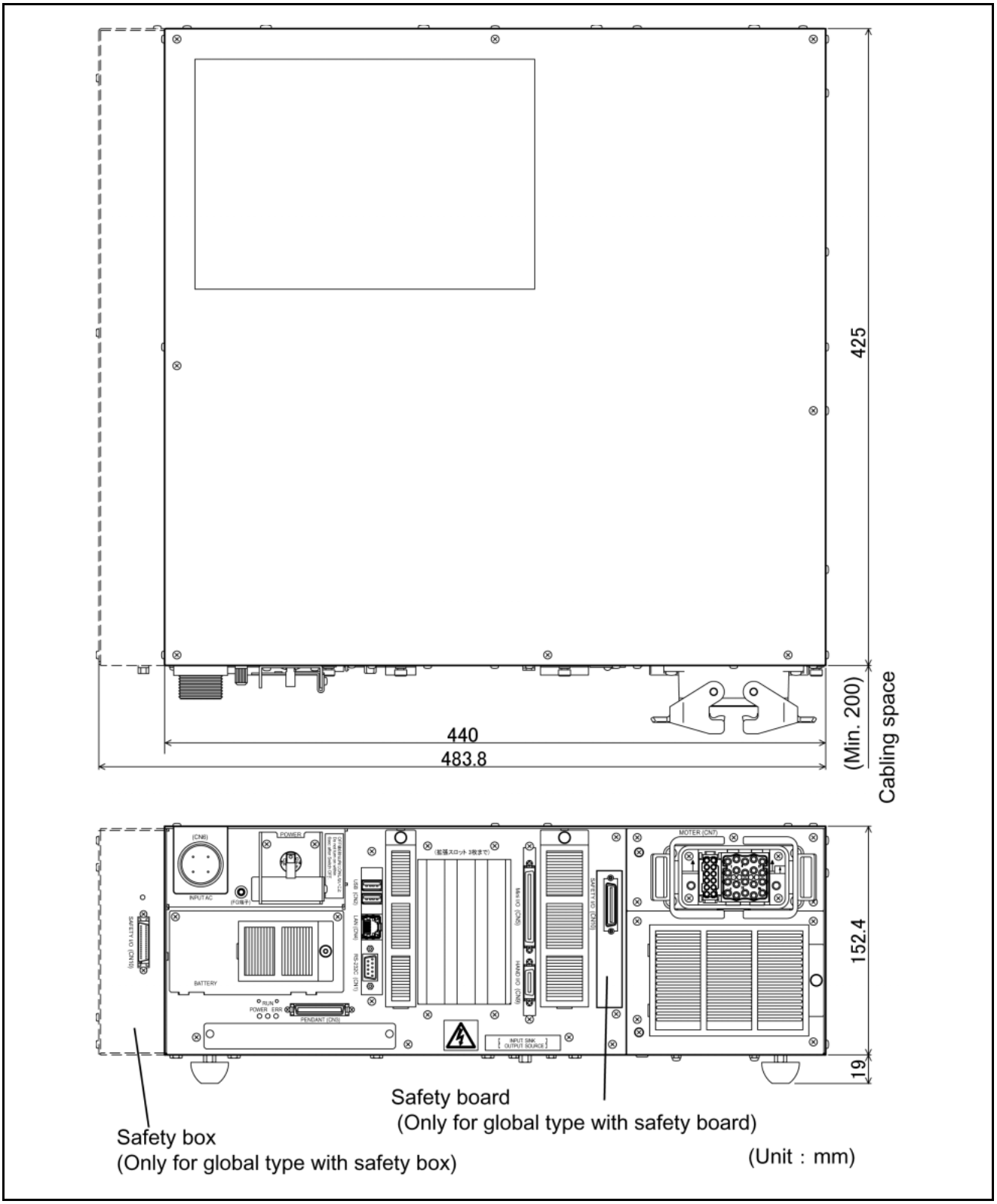
⚠CAUTION IN INSTALLATION

- **This controller is not designed to be dust-proof, splash-proof, or explosion-proof.**
- **Read operation-manuals before installation.**
- **Do not place anything on the controller.**

4.2 Outer Dimensions

Figure below shows the outer dimensions of the robot controller.

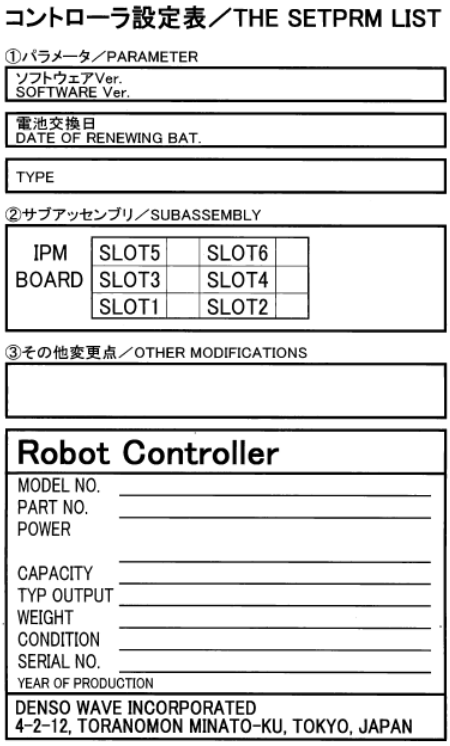
Outer Dimensions of Robot Controller (VP-G series)



Outer Dimensions of RC7M Robot Controller

4.3 Controller Setting Table

The controller setting table given in Figure below is attached to the controller. It shows the software version, the next replacement dates of the memory backup battery and encoder backup battery, etc.


コントローラ設定表／THE SETPRM LIST

①パラメータ／PARAMETER

ソフトウェアVer.
SOFTWARE Ver.

電池交換日
DATE OF RENEWING BAT.

TYPE

②サブアッセンブリ／SUBASSEMBLY

IPM BOARD	SLOT5		SLOT6	
	SLOT3		SLOT4	
	SLOT1		SLOT2	

③その他変更点／OTHER MODIFICATIONS

Robot Controller

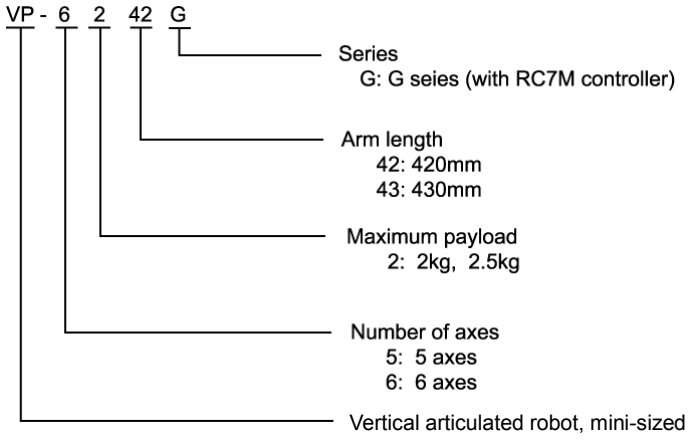
MODEL NO.
PART NO.
POWER
CAPACITY
TYP OUTPUT
WEIGHT
CONDITION
SERIAL NO.
YEAR OF PRODUCTION

DENSO WAVE INCORPORATED
4-2-12, TORANOMON MINATO-KU, TOKYO, JAPAN

<Content THE SETPRM LIST>

SOFTWARE Ver.	The version of the main software for the controller is entered.
DATE OF RENEWING BAT.	The next replacement dates of the memory backup battery and encoder backup battery are entered.
TYPE	The model of the robot system is entered. The coding of the set model is described below:
SUBASSEMBLY	The type and position of the controller IPM board are described.

The coding of the set model (VP-G series)



Chapter 5 Warranty

DENSO robots are manufactured under strict quality control. In case of failure, we warranty the robot under the following conditions:

Warranty Period

The warranty shall be effective for one year from the date of purchase.

Warranty Coverage

DENSO WAVE shall repair the robot free of charge when a failure occurs and is attributable to the design, manufacture or material of the robot within the warranty period in spite of proper use.

Items Not Covered

Failures, which arise from one of the following, shall not be covered by the warranty even if the robot is under warranty:

(1) Failures caused by improper repair, modification, transfer or handling by you or a third party;

(2) Failures caused by the use of a part or oil/fat other than those specified in the related manuals;

(3) Failures caused by a fire, salt damage, earthquake, storm/flood or other acts of God;

(4) Failures caused by the use of the robot in an environment other than the environment specified in the related manuals, such as dust and water ingress;

(5) Failures caused by a worn-out consumable, such as a fan filter;

(6) Failures caused by improper performance or non-performance of lubrication, maintenance or inspections stated in this owner's manual; and

(7) Damages other than the robot repair costs.

Vertical Articulated Robot
VP-G SERIES

GENERAL INFORMATION ABOUT ROBOT

First Edition July 2005
Seventh Edition April 2009
Eighth Edition March 2010

DENSO WAVE INCORPORATED

3M**C

The purpose of this manual is to provide accurate information in the handling and operating of the robot. Please feel 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.