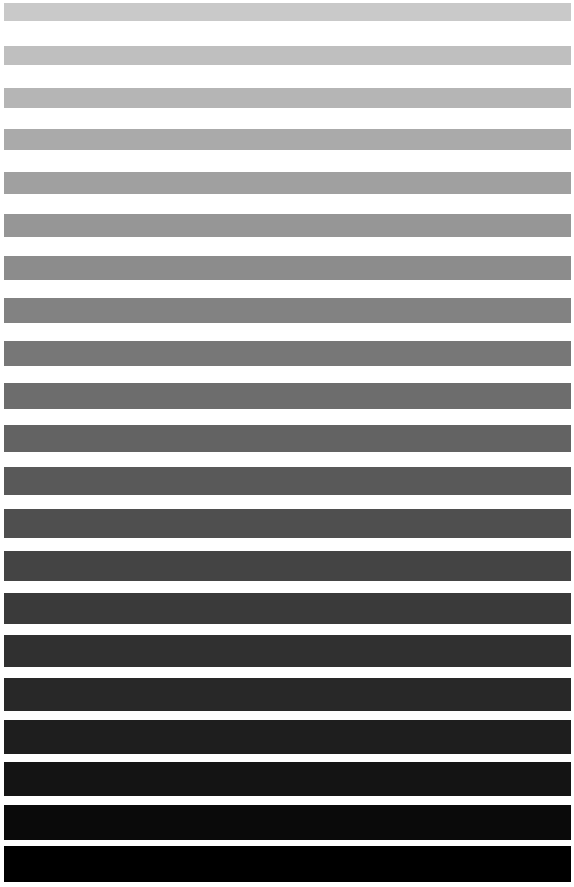
DENSO ROBOT

SUPPLEMENT

Outline of VS-E Series

Chapter 1

General Information about Robot



This chapter touches on general information about the specifications and configuration of the robot.

Contents

General Information about Robot

1.1 Items Contained in the Package

1.1.1 Standard Items

The items listed in Table 1-1 are contained in the product package.

Table 1-1 Standard Items

No.	Item	Q'ty.
(1)	Robot unit	1
(2)	Robot controller	1
(3)	Power cable (5 m) (Note 1)	1
(4)	Robot control cable (Note 2)	1
(5)	Manuals 1) BEGINNER'S GUIDE 2) INSTALLATION & MAINTENANCE GUIDE 3) SETTING-UP MANUAL 4) PROGRAMMER'S MANUAL 5) ERROR CODE TABLES 6) NetwoRC CD (containing WINCAPSII beta version and robot documents)	1 each
(6)	Spare fuse for robot controller	3
(7)	Initialization floppy disk (1.44 MB format) (Note 3)	1
(8)	Pendantless connector (Dummy connector)	1
(9)	Connector set for end-effector control signals (for CN20 and CN21)	1 set
(10)	Power connector for I/O	1
(11)	Direction indicator label (Note 4)	1
(12)	Warning label (Note 5)	1
(13)	Spare output IC for robot controller	1
(14)	Positioning pin set (internally threaded positioning pin and diamond-shaped pin) (Note 6)	1 set

Note 1: Not only the standard power cable but also the UL-compliant one is available. The CE-compliant one consists of a power connector only.

Note 2: Select a proper robot control cable from Tables 1-2 (a) and (b).

Note 3: Preserve the initialization floppy disk in a safe place. The disk contains arm data in WINCAPSII format. If a memory error appears on the teach pendant due to memory failure, use the disk to load the arm data to the robot controller. (Refer to Section 6.13 "Using the Initialization Floppy Disk.")

Note 4: Attach the direction indicator label in a position on the robot unit that can be easily seen after installation.

Note 5: Attach the warning label on the robot safety fence or other location where workers will notice it.

If necessary, prepare a plate for attaching the seal.

Note 6: The positioning pin set is provided only for the VS-E series as a standard component.

TIP: The VS-D series may provide an extended-joint support system (capable of controlling up to two extended-joints). For details about the extended-joint support system, refer to the SUPPLEMENT (No. 410002-6090) to the robot instruction manuals.

Table 1-2 (a) VM-D & VS-E Robot Control Cables

No.	Cable		Part No. (CE- &UL-compliant)
(1)	Standard cable	4 m	410141-1950
(2)	Standard cable	6 m	410141-1960
(3)	High-strength cable	6 m	410141-1990
(4)	High-strength cable	12 m	410141-2000
(5)	Splash-proof cable	4 m	410141-1970
(6)	Splash-proof cable	6 m	410141-1980
(7)	Splash-proof, high-strength cable	6 m	410141-2010
(8)	Splash-proof, high-strength cable	12 m	410141-2020

Table 1-2 (b) VS-D Robot Control Cable Sets (Motor cable & encoder cable)

No.	Cable		Part No. (CE-compliant)
(1)	Standard cable set	3 m	410149-0520
(2)	Standard cable set	6 m	410149-0530
(3)	Splash-proof cable set	3 m	—
(4)	Splash-proof cable set	6 m	—

1.1.2 Optional Items

Table 1-3 lists the optional items.

Table 1-3 Optional Items (1)

Classification	No.	Item	Remarks	Part No.
I/O cable	1	I/O cable set	(8 m) (Consists of Nos.1-1 to 1-3, one each)	410149-0330
	1-1	Input cable	(8 m)	410141-1630
	1-2	Output cable	(8 m)	410141-1650
	1-3	End-effector I/O cable	(8 m)	410141-1740
	2	I/O cable set (Only the end-effector I/O cable is a high-strength type.)	(8 m) (Consists of Nos.2-1 to 2-3, one each)	410149-0350
	2-1	Input cable	(8 m)	410141-1630
	2-2	Output cable	(8 m)	410141-1650
	2-3	End-effector I/O cable (high-strength)	(8 m)	410141-1670
I/O cable	3	I/O cable set	(15 m) (Consists of Nos.3-1 to 3-3, one each)	410149-0340
	3-1	Input cable	(15 m)	410141-1640
	3-2	Output cable	(15 m)	410141-1660
	3-3	End-effector I/O cable	(15 m)	410141-1750
	4	I/O cable set (Only the end-effector I/O cable is a high-strength type.)	(15 m) (Consists of Nos.4-1 to 4-3, one each)	410149-0360
	4-1	Input cable	(15 m)	410141-1640
	4-2	Output cable	(15 m)	410141-1660
	4-3	End-effector I/O cable (high-strength)	(15 m)	410141-1680
Operating panel	5	Operating panel (Note 1)	(4 m)	410100-0970
	6	Operating panel (Note 1)	(8 m)	410100-0980
Pendant	7	Teach pendant (Note 1)	(4 m)	410100-0940
	8	Teach pendant (Note 1)	(8 m)	410100-0950
	9	Teach pendant (Note 1)	(12 m)	410100-0960
	10	Mini pendant	(4 m)	410109-0020
	11	Mini pendant	(8 m)	410109-0040
	12	Mini pendant	(12 m)	410109-0060

Note 1:The total cable length must not be more than 12 m when the operating panel and the teach pendant are to be connected in series.

(Continued on the following page.)

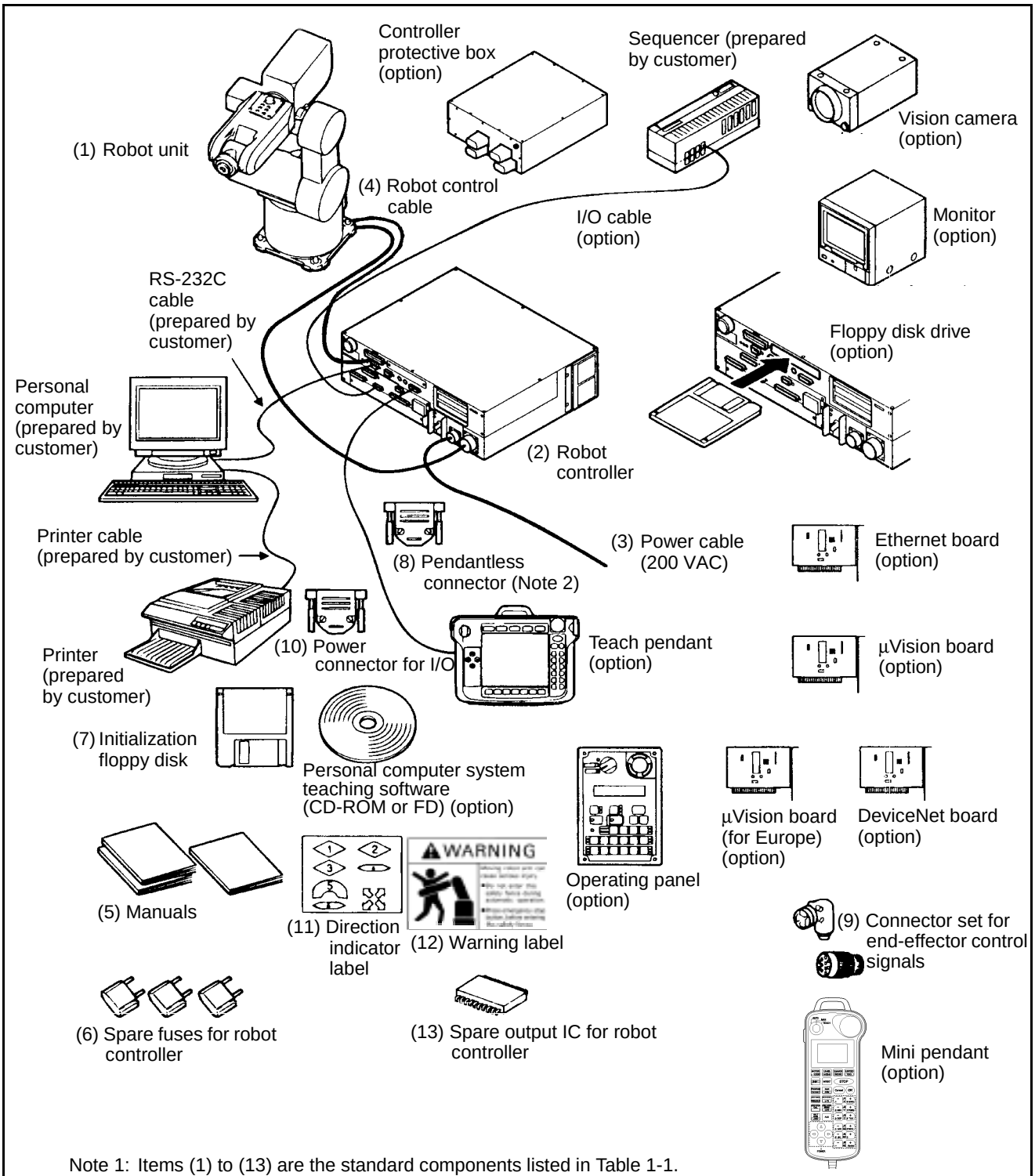
Table 1-3 Optional Items (2)

Classification	No.	Item	Remarks		Part No.
Software	13	WINCAPSII	(in CD-ROM)		410090-0860
	14	WINCAPSII	(in floppy disk)		410090-0870
Visual system	15	µVision (built-in visual) board	(NTSC)	For models except VM-6070D	410010-0690
				For VM-6070D	410010-0470
	16	µvision (built-in visual) board (for Europe)	(PAL)	For models except VM-6070D	410010-0700
				For VM-6070D	410010-0560
	17	Camera			463980-0030
	18	Monitor			463980-0020
	19	Camera cable	(3 m)		463981-0110
	20	Camera cable	(5 m)		463981-0120
	21	Camera cable	(15 m)		463981-0160
	22	Monitor cable	(BNC) (1 m)		463981-0010
	23	Monitor cable	(BNC) (3 m)		463981-0030
	24	Monitor cable	(BNC) (5 m)		463981-0050
Others	25	Ethernet board	For models except VM-6070D		410010-0710
			For VM-6070D		410010-0460
	26	Built-in floppy disk drive (for 1.44 MB floppy disk)			410010-0520
	27	Controller protection box	For VM-D		410181-0030
			For VS-D/-E		410181-0060
	28	DeviceNet board (Slave station)	For models except VM-6070D		410010-0720
			For VM-6070D		410010-0450
	29	DeviceNet board (Master station)	Not applicable to the VM-6070D		410010-0740
	30	PROFIBUS board (Slave station)			410010-1190
	31	I/O connector set for RC5	For parallel I/O		410159-0070
	32	Transformer box (for VM-D destined for Europe)	From 400 VAC 3-phase to 200 VAC 3-phase		410000-7130

1.2 Robot Configuration

1.2.1 Robot System

Figure 1-1 shows the entire configuration of the robot system.



Note 1: Items (1) to (13) are the standard components listed in Table 1-1.

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

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

Figure 1-1 Robot Components

1.2.2 Names of Robot Unit Components

Figure 1-2 shows the names of the components of the robot unit and the rotation direction of each axis.

■ VS-E Series

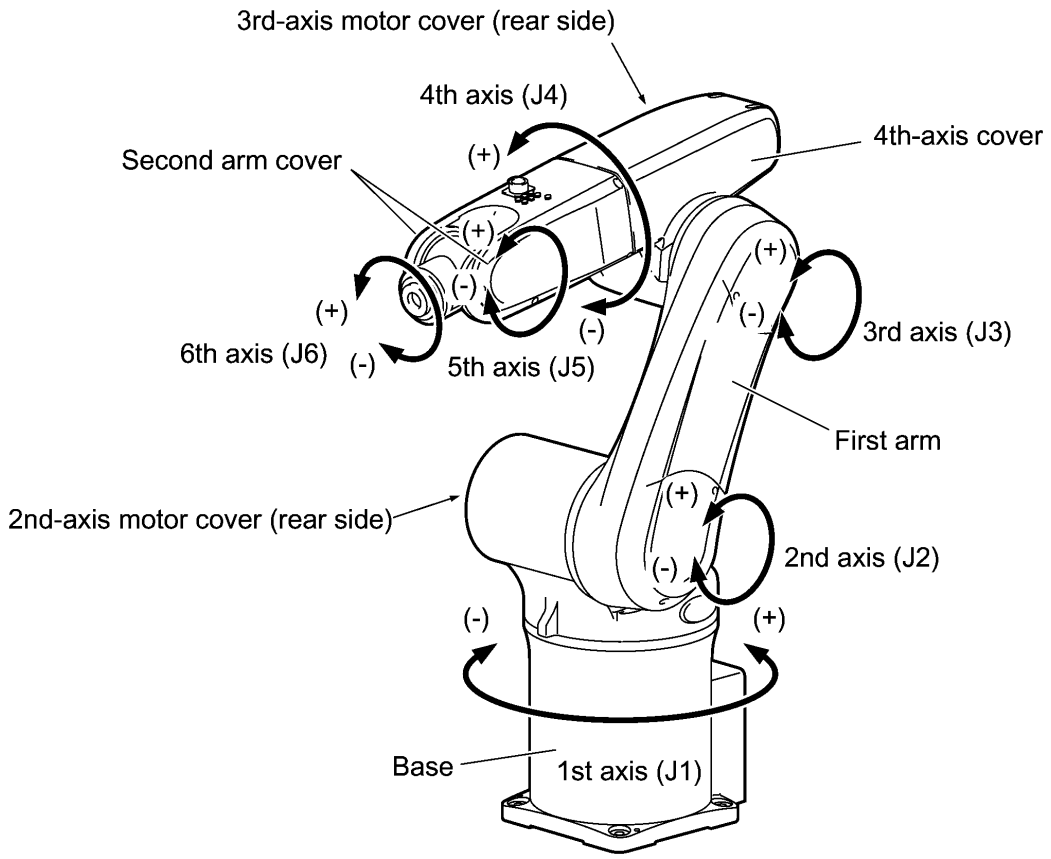


Figure 1-2 Names of Components (VS-E series)

1.2.3 Names of the Robot Controller Components

Figure 1-3 and Table 1-4 show the names of the robot controller components.

■ VS-E Series

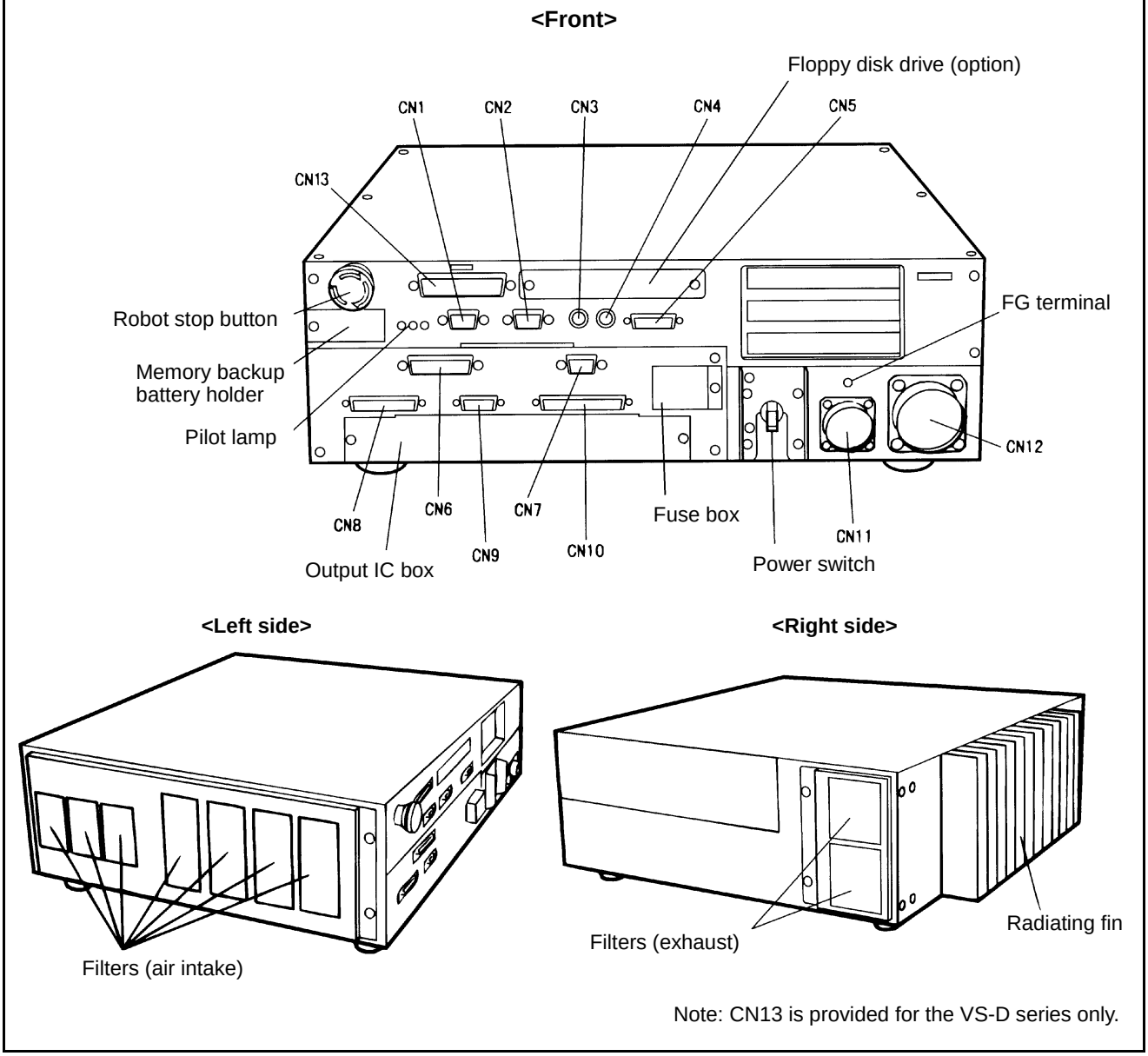


Figure 1-3 Names of Robot Controller Components (VS-E series)

Table 1-4 Connector Names (VS-E series)

Connector No.	Marking	Name	Connector No.	Marking	Name
CN1	RS232C	Serial interface connector	CN7	I/O POWER	Power connector for I/O
CN2	CRT	CRT connector	CN8	INPUT	Connector for user input or system input
CN3	KEYBD	Keyboard connector	CN9	HAND I/O	Connector for end-effector I/O
CN4	MOUSE	Connector for PS/2 mouse	CN10	OUTPUT	Connector for user output or system output
CN5	PENDANT	Connector for teach pendant	CN11	INPUT AC	Power connector
CN6	PRINTER	Printer connector (Not used.)	CN12	MOTOR	Connector for motor/encoder

⚠Caution: The robot controller connectors are of a screw-lock type or ring-lock type. Lock the connectors securely. If even one of the connectors is not locked, weak contact may result thereby causing an error.

Be sure to turn the robot controller OFF before connecting/ disconnecting the power connector or motor connector. Otherwise, the internal circuits of the robot controller may be damaged.

1.3 Robot Specifications

■ VS-E Series

[1] Robot Unit Specifications

Table 1-10 lists the robot unit specifications of the VS-E series.

(1) VS-6556E

Table 1-10 (a) VS-6556E Specifications

Item		Specifications			
		Standard type	Dust-proof & splash-proof type	With brakes	Dust-proof & splash-proof type with brakes
Model name of robot set **(Note 1)**		VS-6556E	VS-6556E-W	VS-6556E-B	VS-6556E-BW
Model name of robot unit		VS-6556EM	VS-6556EM-W	VS-6556EM-B	VS-6556EM-BW
Overall arm length		270 (first arm) + 295 (second arm) = 565 mm			
Arm offset		J1 (swing): 75 mm, J3 (front arm): 90 mm			
Maximum motion area		R = 733 mm (end-effector mounting face) R = 653 mm (Point P: J4, J5, J6 center)			
Motion range		J1 : ±170°, J2 : +135°, -100°, J3 : +166°, -119° J4 : ±190°, J5 : ±120°, J6 : ±360°			
Maximum payload		5 kg			
Maximum composite speed		8200 mm/s (at the center of an end-effector mounting face)			
Position repeatability **(Note 2)**		In each of X, Y and Z directions: ±0.02 mm			
Maximum allowable inertia moment		Around J4 and J5: 0.295 kgm^2 Around J6: 0.045 kgm^2			
Position detection		Simplified absolute encoder			
Drive motor and brake		AC servomotors for all joints, Brakes for joints J2 to J4		AC servomotors for all joints, Brakes for joints J2 to J6	
User air piping **(Note 3)**		7 systems (ϕ4x6, ϕ6x1), 3 solenoid valves (2-position, double solenoid) contained.			
User signal line		10 (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			
Weight		Approx. 28 kg			

Note 1: The model name of robot set refers to the model name of a complete set including a robot unit and robot controller.

Note 2: Position repeatability is the value at constant ambient temperature.

Note 3: Only the ϕ4x6 air piping system may be controlled by built-in solenoid valves.

(2) VS-6577E

Table 1-10 (b) VS-6577E Specifications

Item		Specifications			
		Standard type	Dust-proof & splash-proof type	With brakes	Dust-proof & splash-proof type with brakes
Model of robot system **(Note 1)**		VS-6577E	VS-6577E-W	VS-6577E-B	VS-6577E-BW
Model of robot unit		VS-6577EM	VS-6577EM-W	VS-6577EM-B	VS-6577EM-BW
Overall arm length		365 (first arm) + 405 (second arm) = 770 mm			
Arm offset		J1 (swing): 75 mm, J3 (front arm): 90 mm			
Maximum motion area		R = 934 mm (end-effector mounting face) R = 854 mm (Point P: J4, J5, J6 center)			
Motion range		J1 : ±170°, J2 : +135°, -100°, J3 : +169°, -119° J4 : ±190°, J5 : ±120°, J6 : ±360°			
Maximum payload		5 kg			
Maximum composite speed		7600 mm/s (at the center of an end-effector mounting face)			
Position repeatability **(Note 2)**		In each of X, Y and Z directions: ±0.03 mm			
Maximum allowable inertia moment		Around J4 and J5: 0.295 kgm^2 Around J6: 0.045 kgm^2			
Position detection		Simplified absolute encoder			
Drive motor and brake		AC servomotors for all joints, Brakes for joints J2 to J4		AC servomotors for all joints, Brakes for joints J2 to J6	
User air piping **(Note 3)**		7 systems (φ4x6, φ6x1), 3 solenoid valves (2-position, double solenoid) contained.			
User signal line		10 (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			
Weight		Approx. 29 kg			

Note 1: The model name of robot set refers to the model of a complete set including a robot unit and robot controller.

Note 2: Position repeatability is the value at constant ambient temperature.

Note 3: Only the φ4x6 air piping system may be controlled by built-in solenoid valves.

[2] Outer Dimensions and Workable Space of the Robot Unit

Figure 1-31 shows the outer dimensions and workable space of the VS-E series robot.

(1) VS-6556E (Standard type)

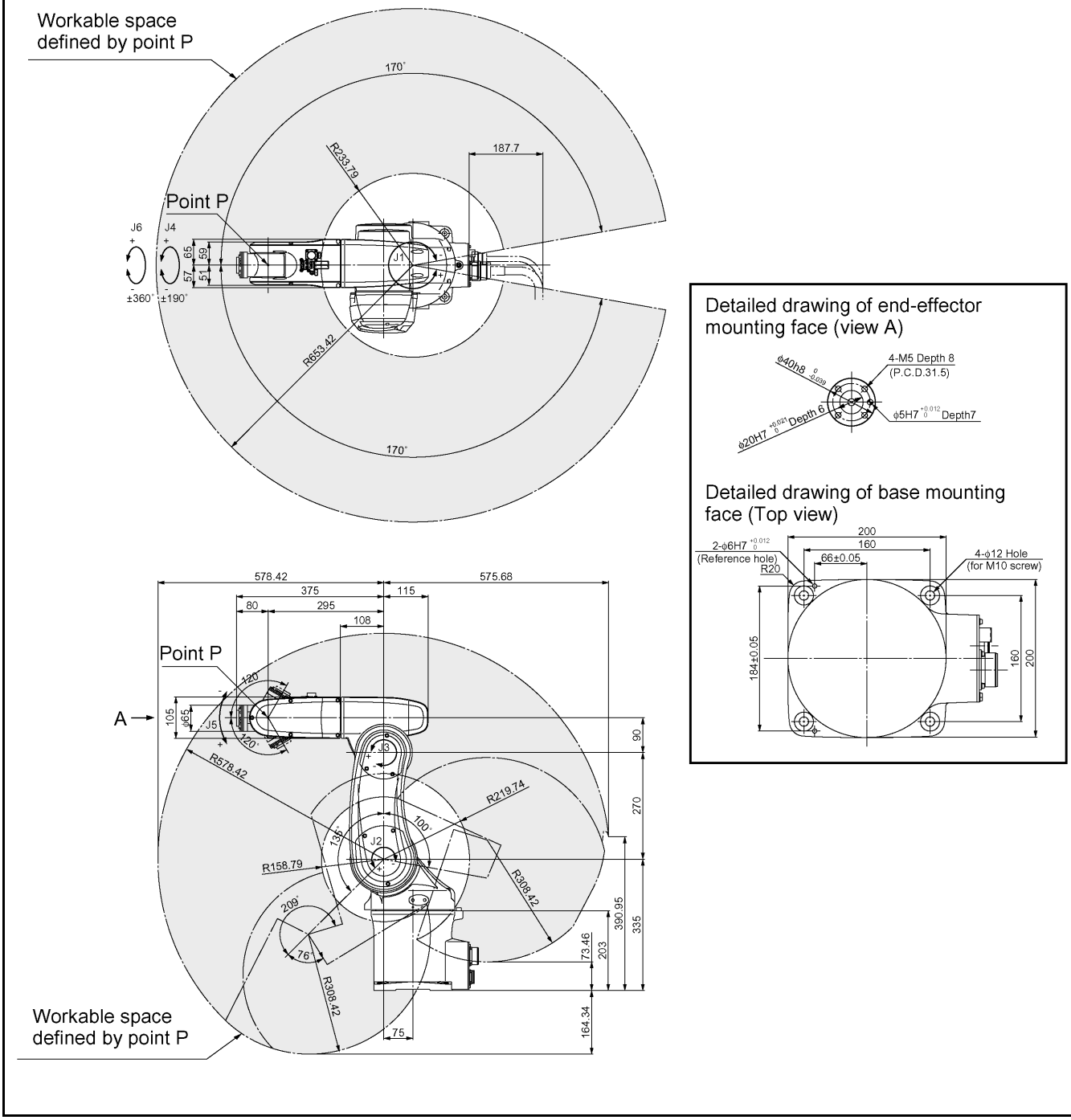


Figure 1-31 (a) Outer Dimensions and Workable Space [VS-6556E]

(2) VS-6556E-W (Dust-proof & splash-proof type)

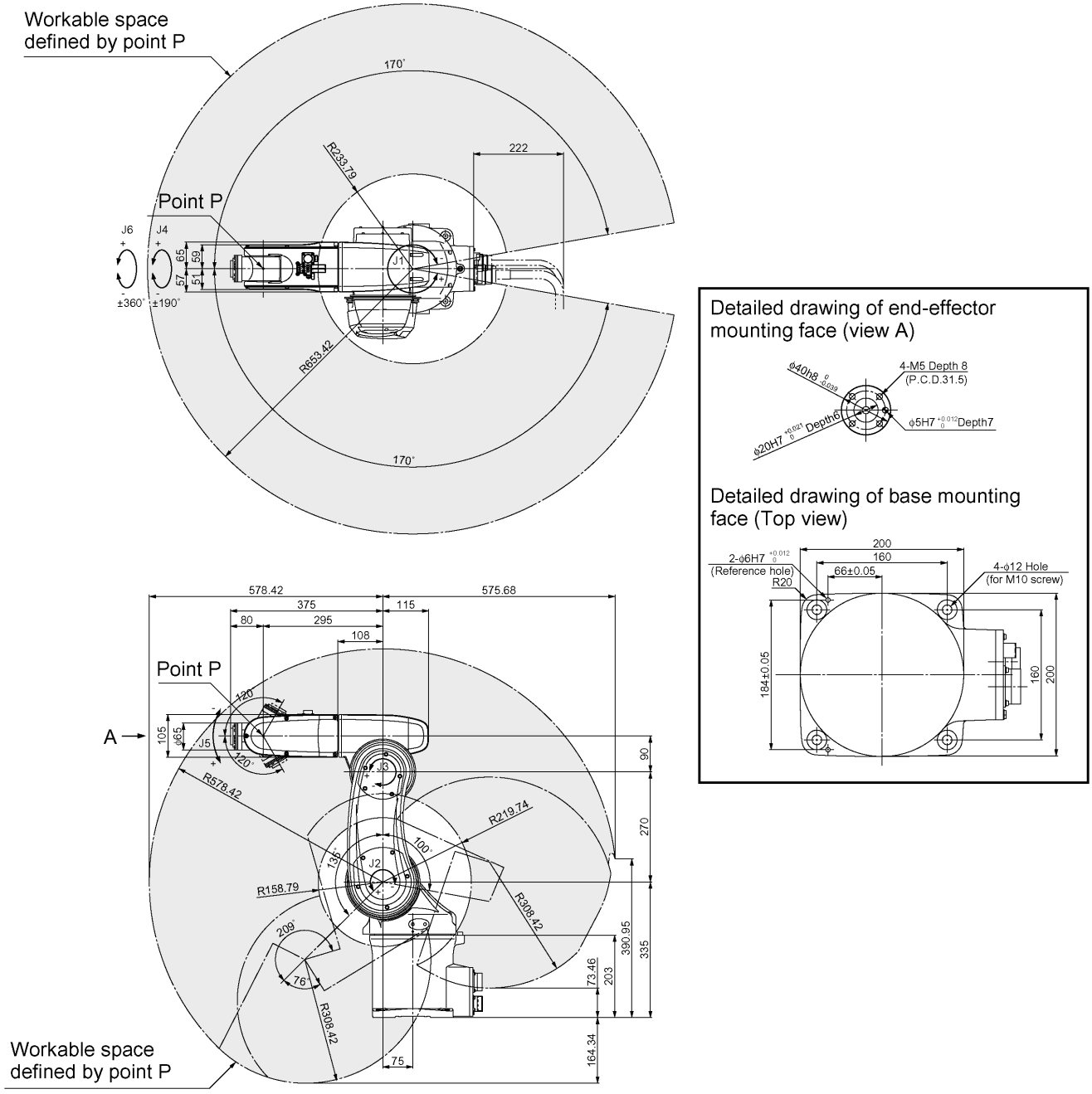


Figure 1-31 (b) Outer Dimensions and Workable Space [VS-6556E-W]

(3) VS-6556E-B (with brakes)

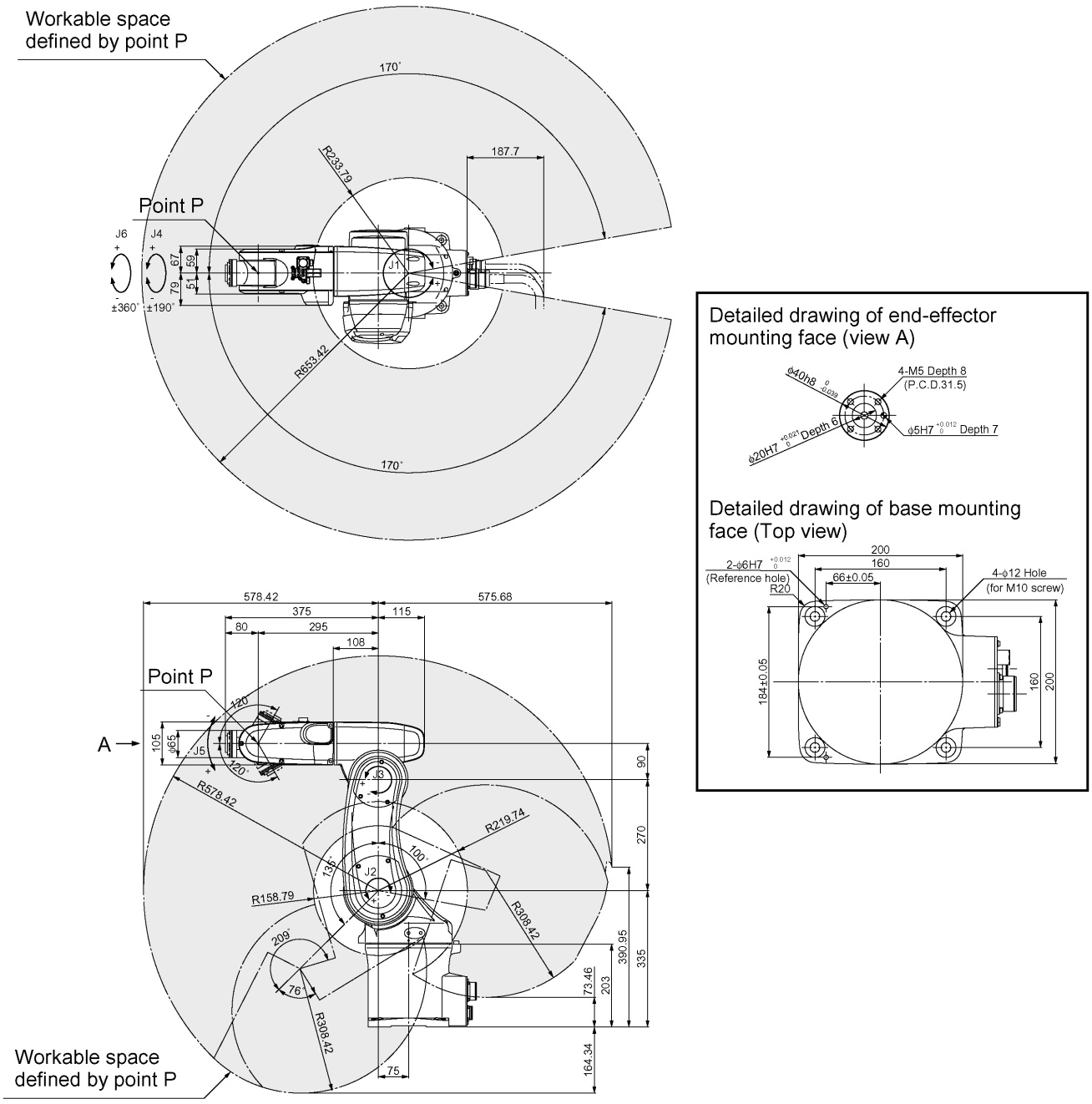


Figure 1-31 (c) Outer Dimensions and Workable Space [VS-6556E-B]

(4) VS-6556E-BW (Dust-proof & splash-proof type with brakes)

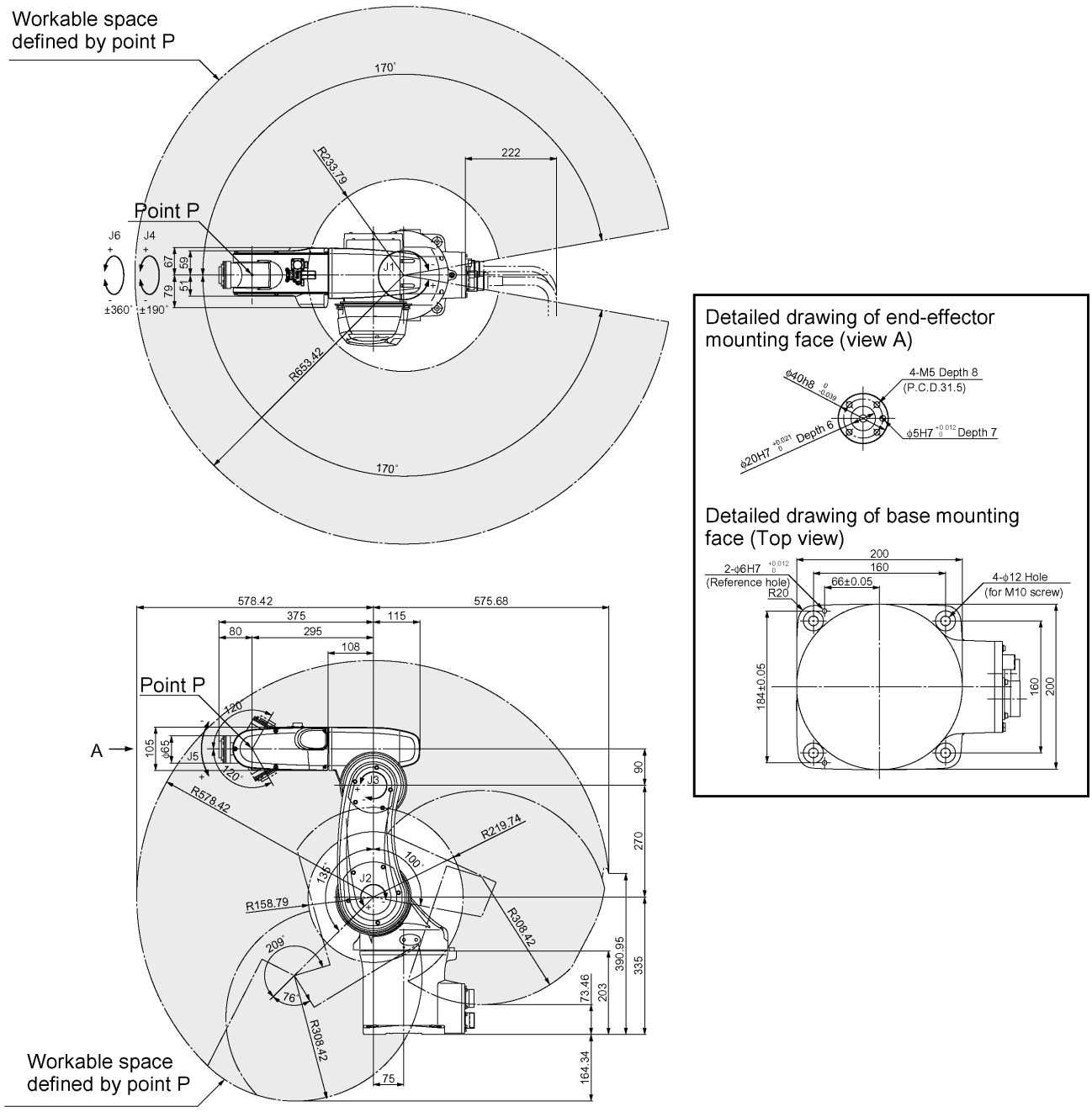


Figure 1-31 (d) Outer Dimensions and Workable Space [VS-6556E-BW]

(5) VS-6577E (Standard type)

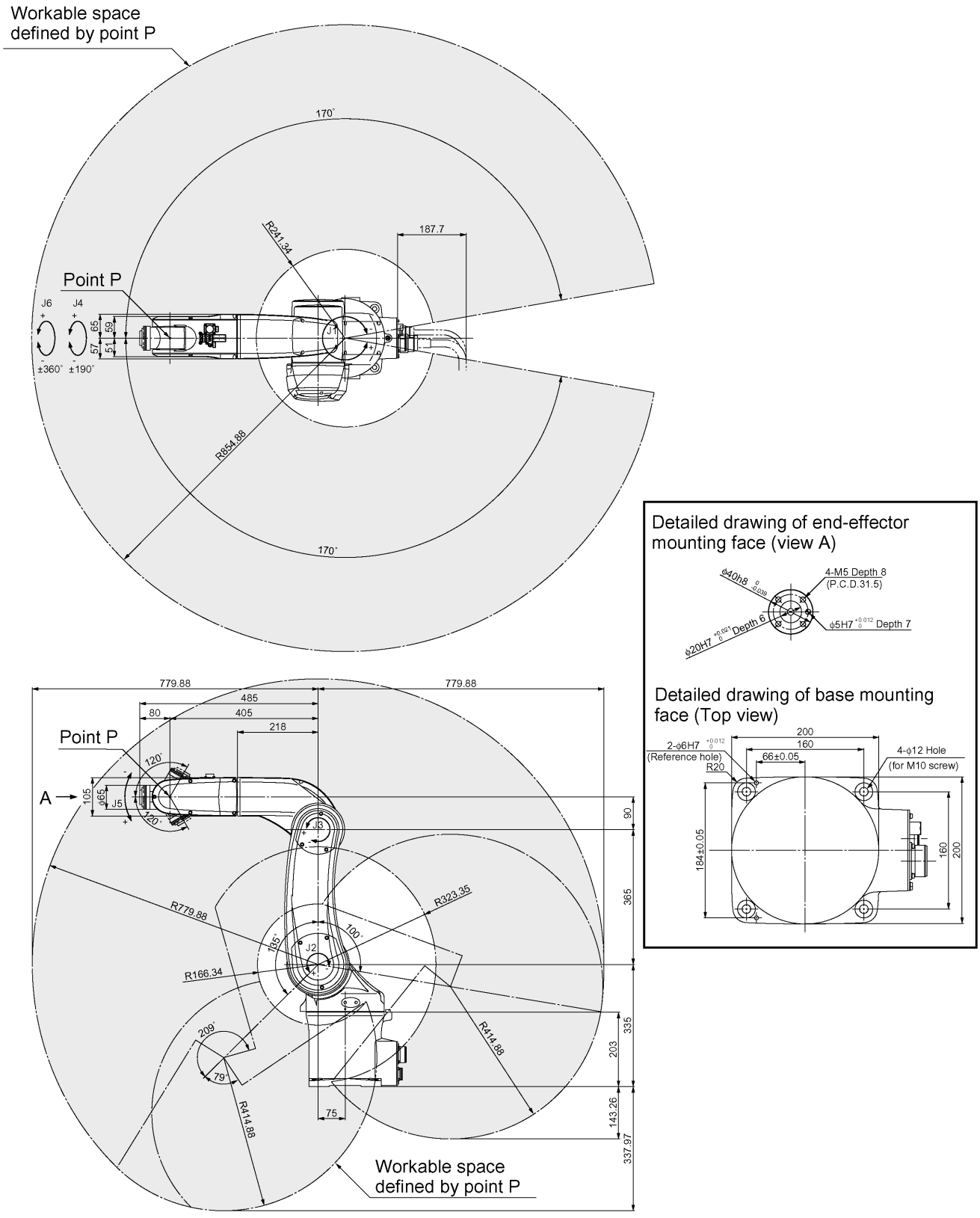


Figure 1-31 (e) Outer Dimensions and Workable Space [VS-6577E]

(6) VS-6577E-W (Dust-proof & splash-proof type)

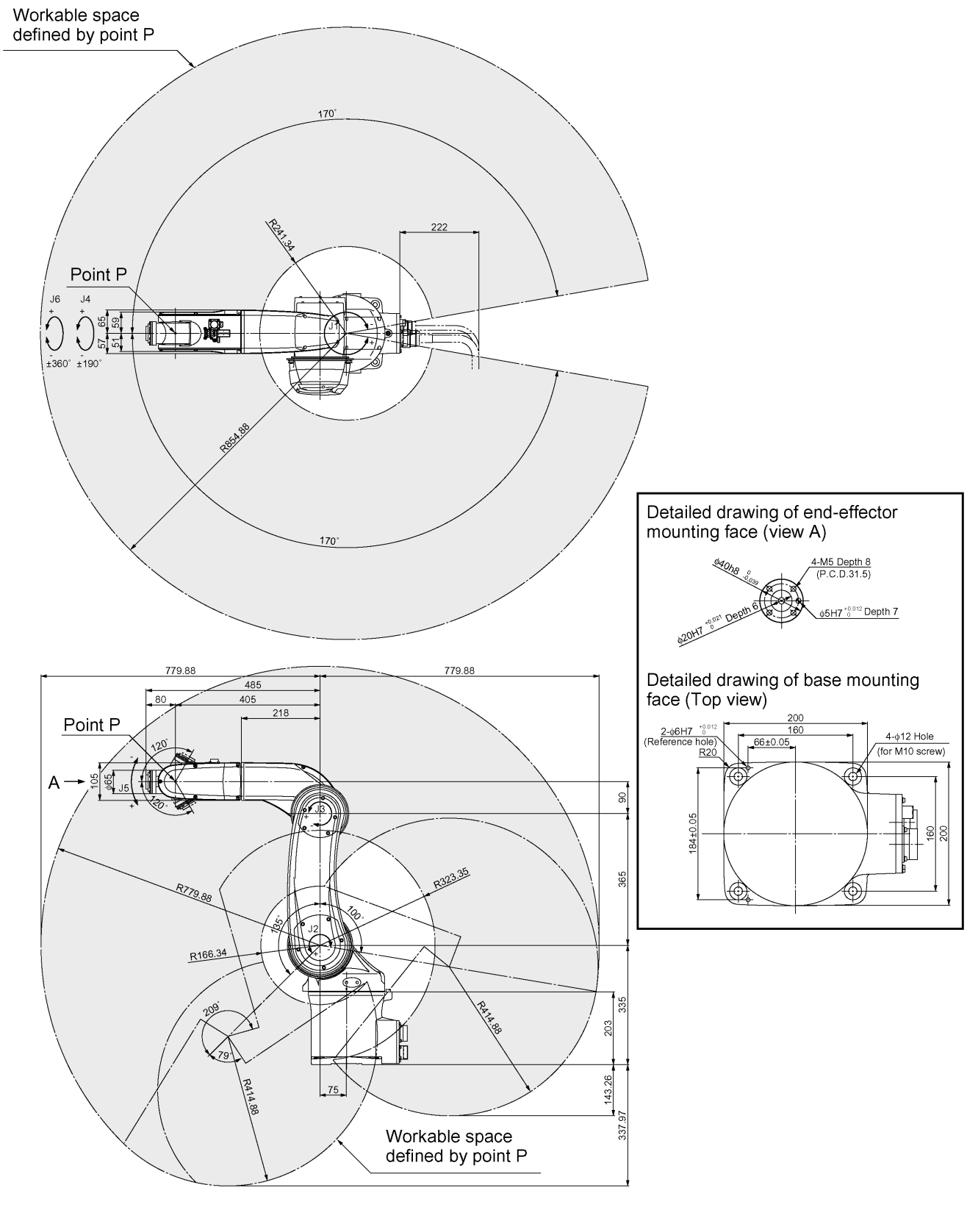


Figure 1-31 (f) Outer Dimensions and Workable Space [VS-6577E-W]

(7) VS-6577E-B (With brakes)

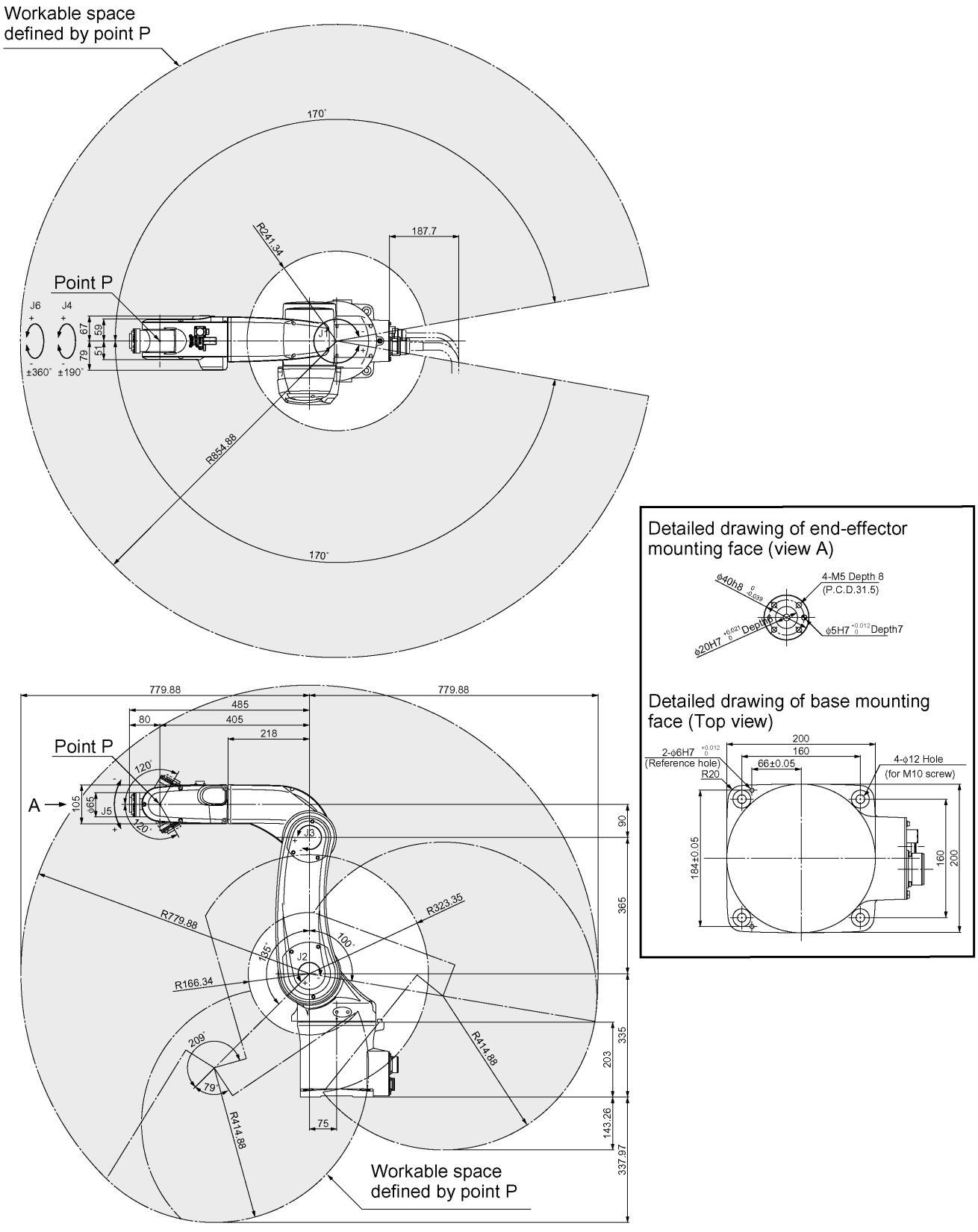


Figure 1-31 (g) Outer Dimensions and Workable Space [VS-6577E-B]

(8) VS-6577E-BW (Dust-proof & splash-proof type with brakes)

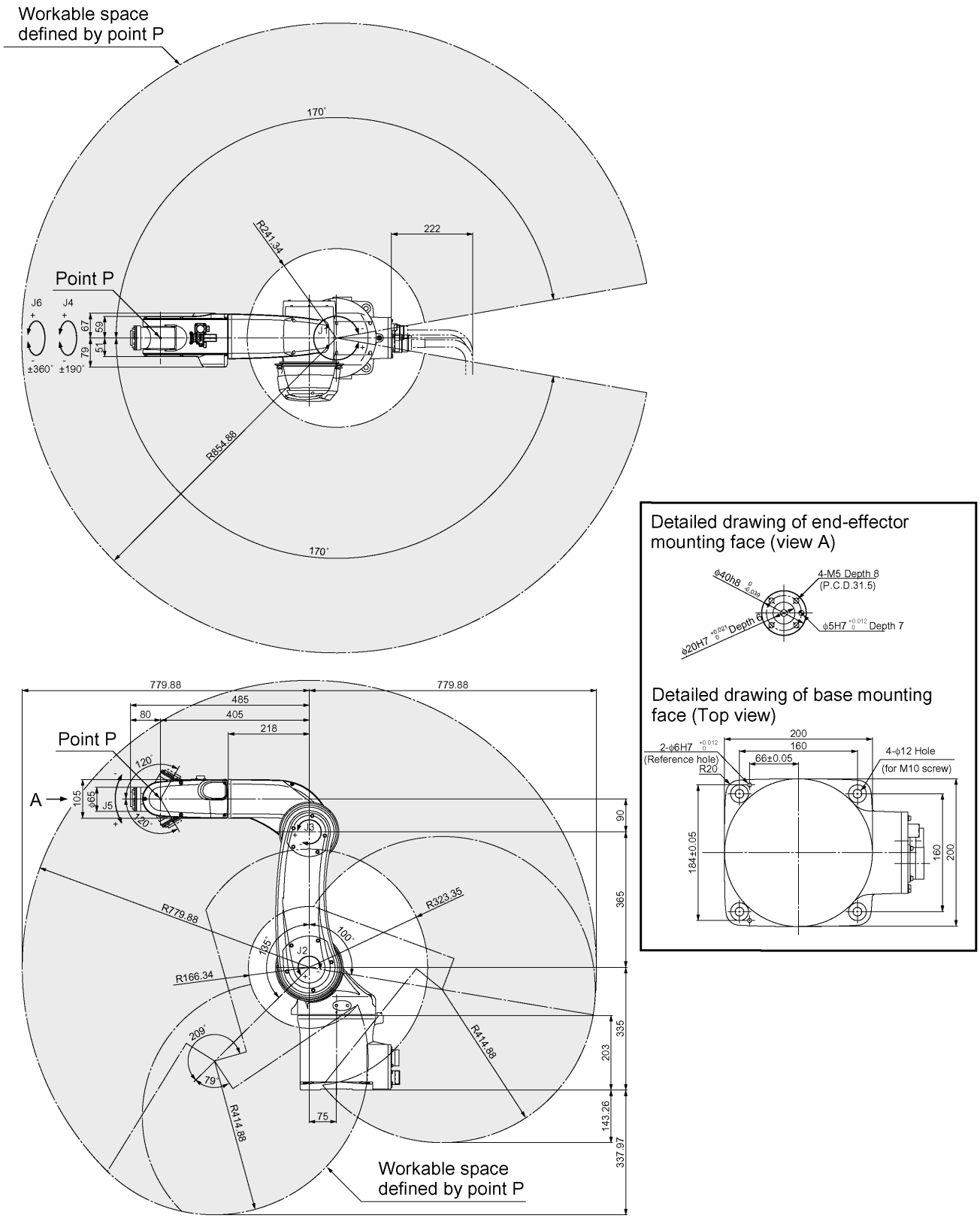


Figure 1-31 (h) Outer Dimensions and Workable Space [VS-6577E-BW]

[3] Robot Positioning Time

VS-E series robot positioning time

1. Figures 1-33 to 1-42 show the positioning times used to calculate the cycle time.
2. Positioning time means the time from the start of robot operation to the arrival at the target positioning point.
3. 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 1-32. 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.

(4) Whenever the payload is heavier than 7 kg, use the robot with the flanged side of the 6th axis facing down. If the flanged side is not facing down, an over-deviation error (code starts from ERROR6100; the first digit represents the axis number), overcurrent error (code starts from ERROR6120; the first digit represents the axis number) or overload error (code starts from ERROR6170; the first digit represents the axis number) may be displayed.

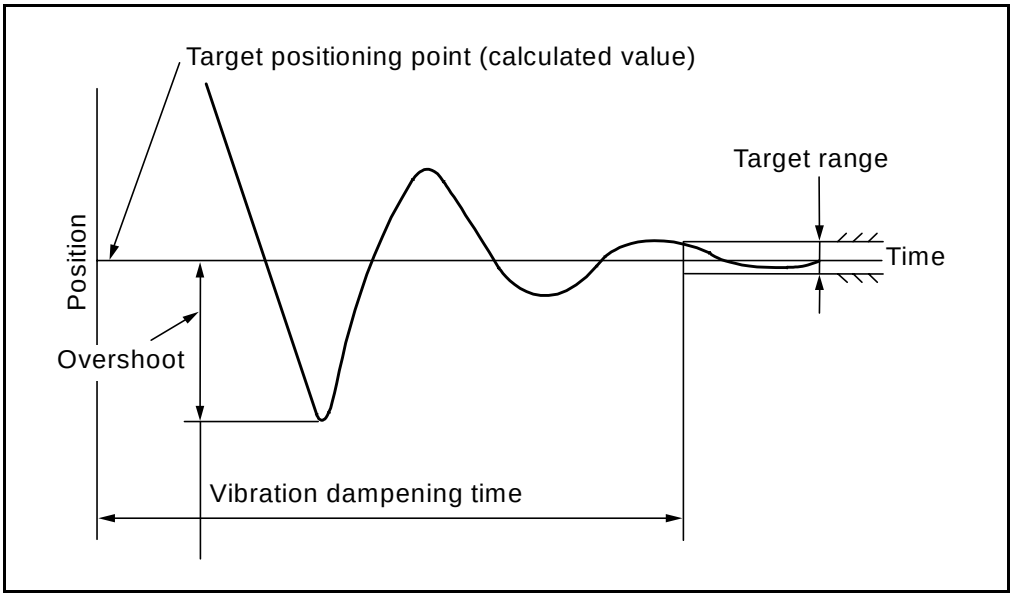


Figure 1-32 Vibration Dampening Time

(1) VS-6556E robot positioning time

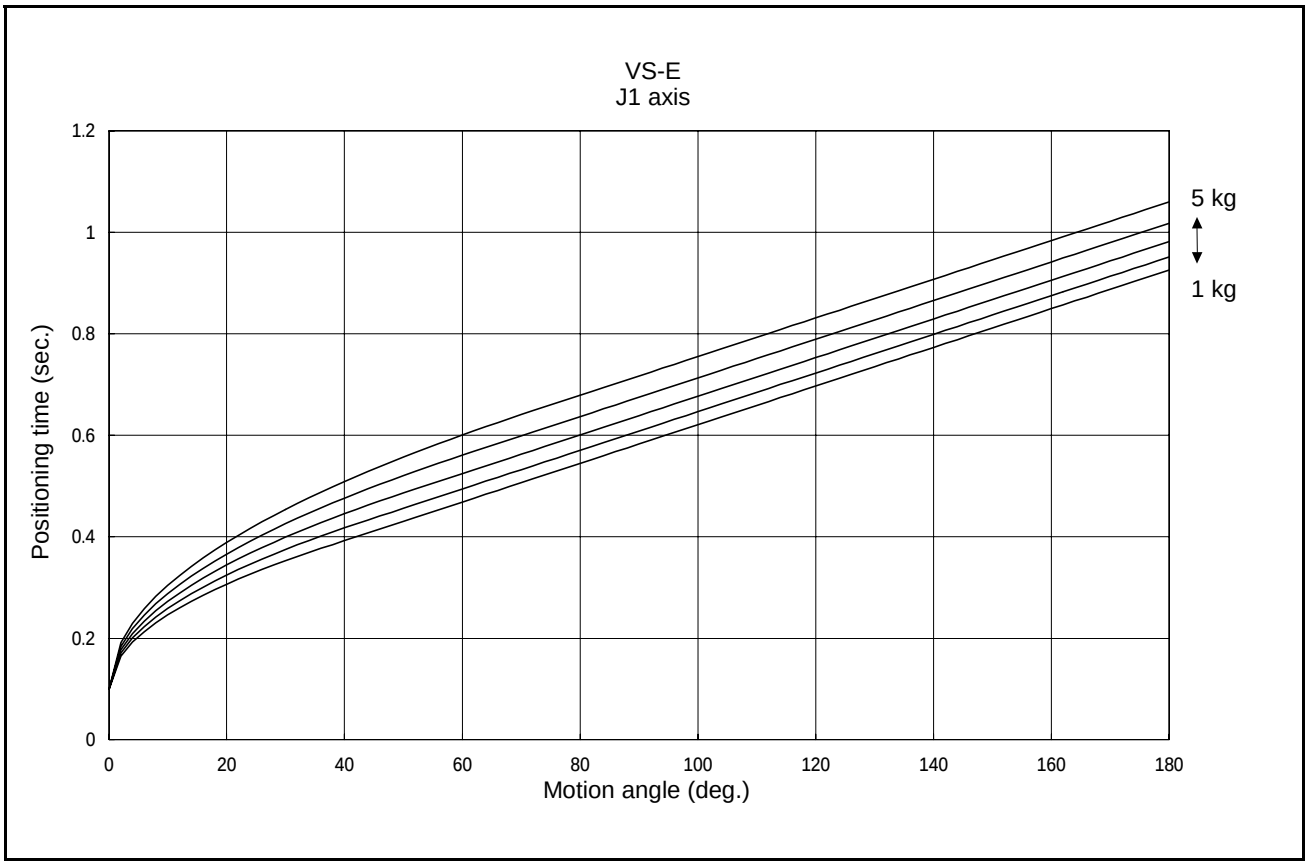


Figure 1-33 J1 Axis [VS-6556E]

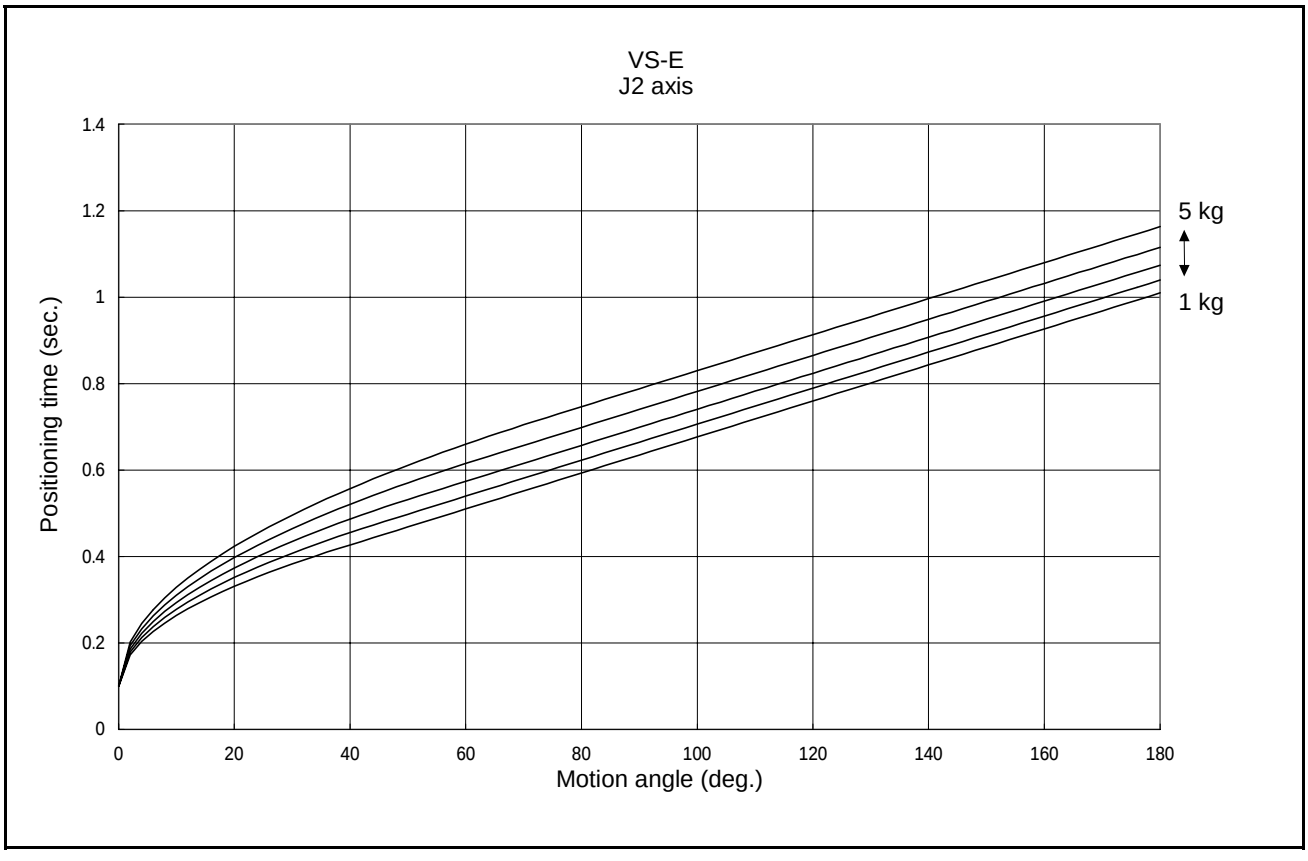


Figure 1-34 J2 Axis [VS-6556E]

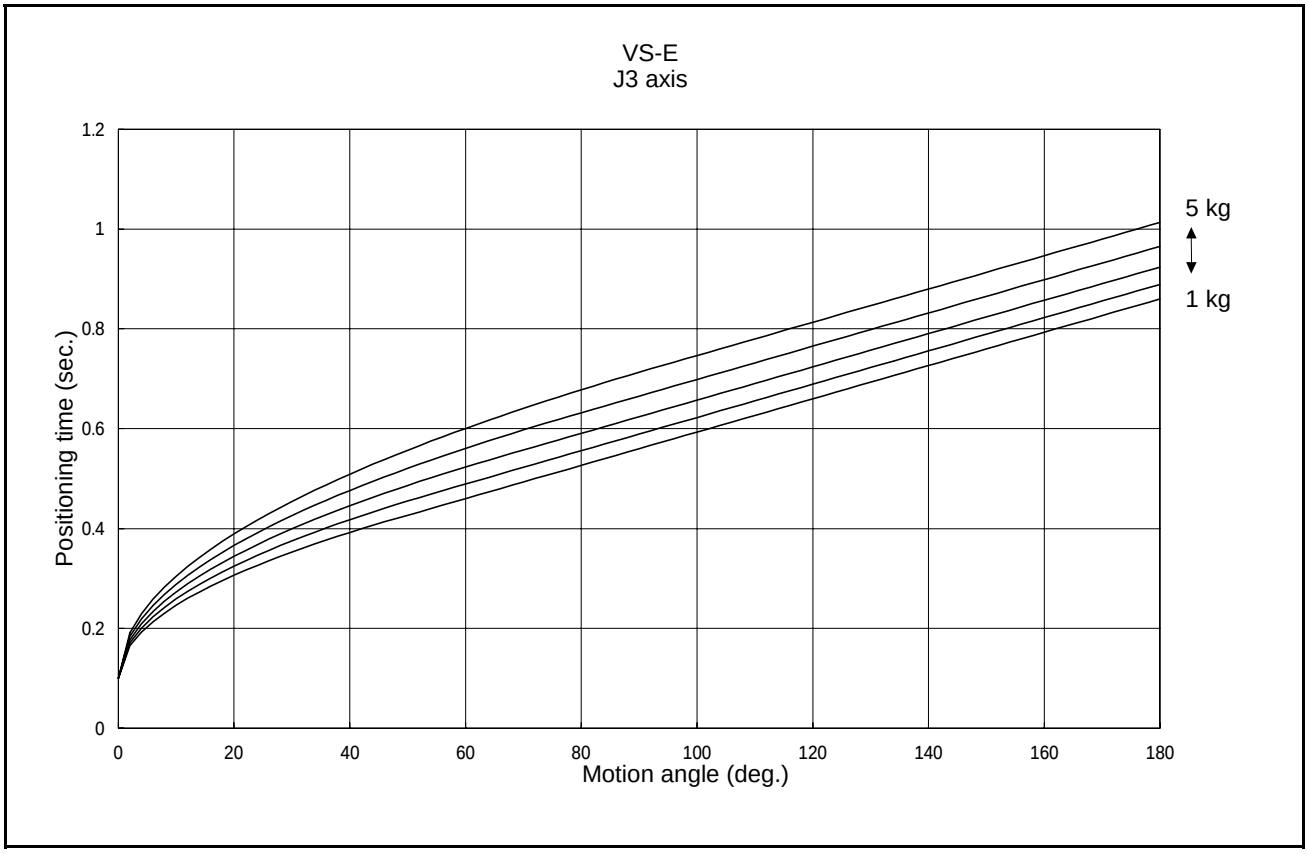


Figure 1-35 J3 Axis [VS-6556E]

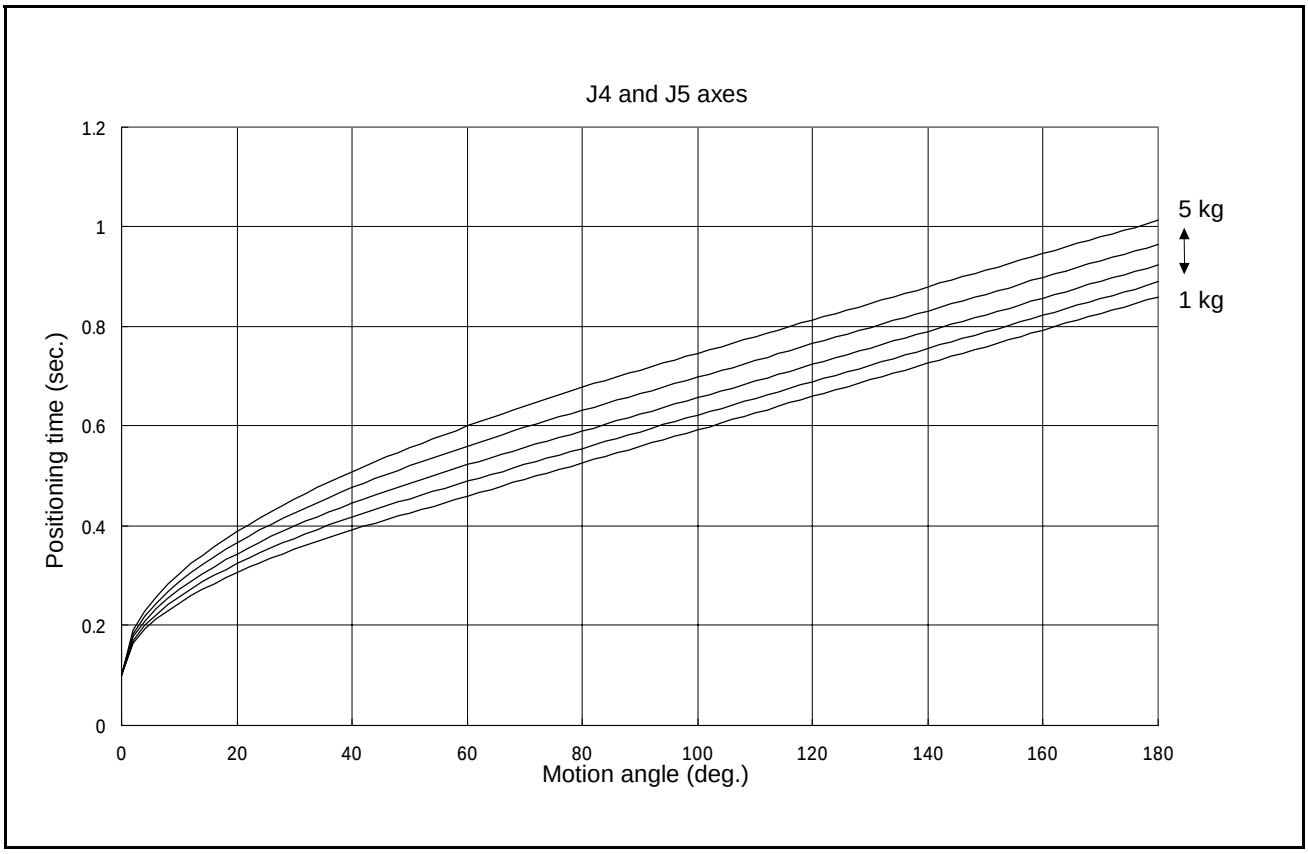


Figure 1-36 J4/J5 Axis [VS-6556E]

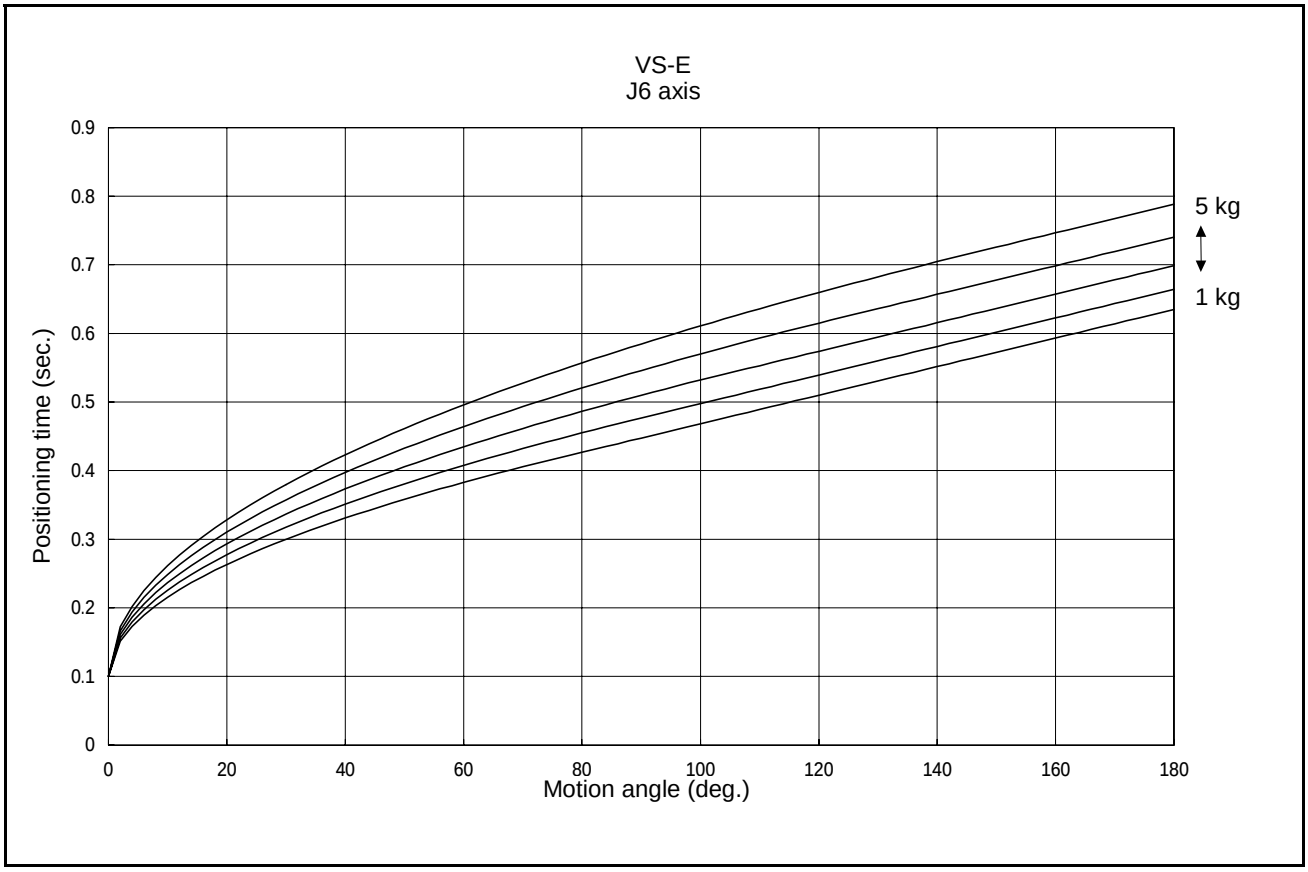


Figure 1-37 J6 Axis [VS-6556E]

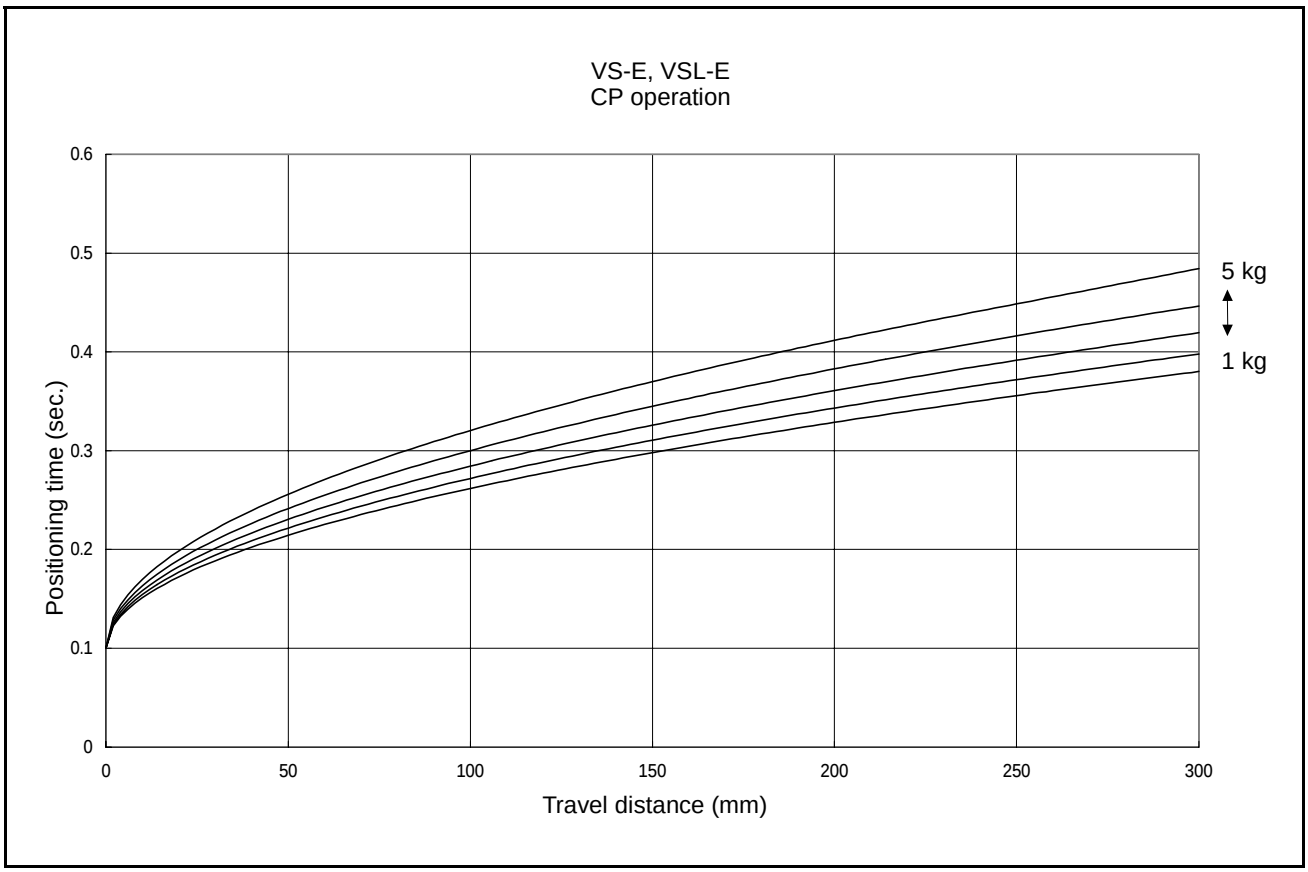


Figure 1-38 CP Operation [VS-6556E]

(2) VS-6577E robot positioning time

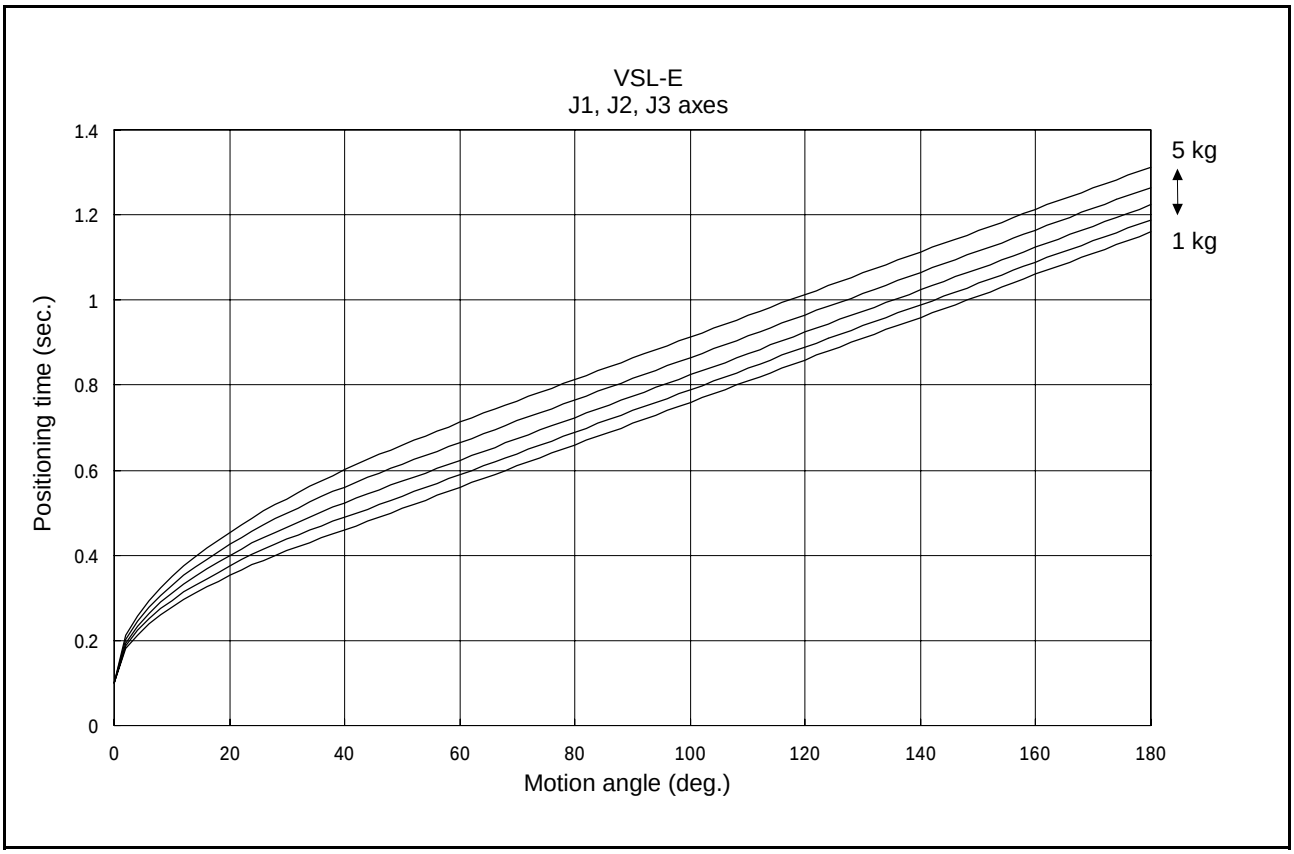


Figure 1-39 J1, J2 and J3 Axes [VS-6577E]

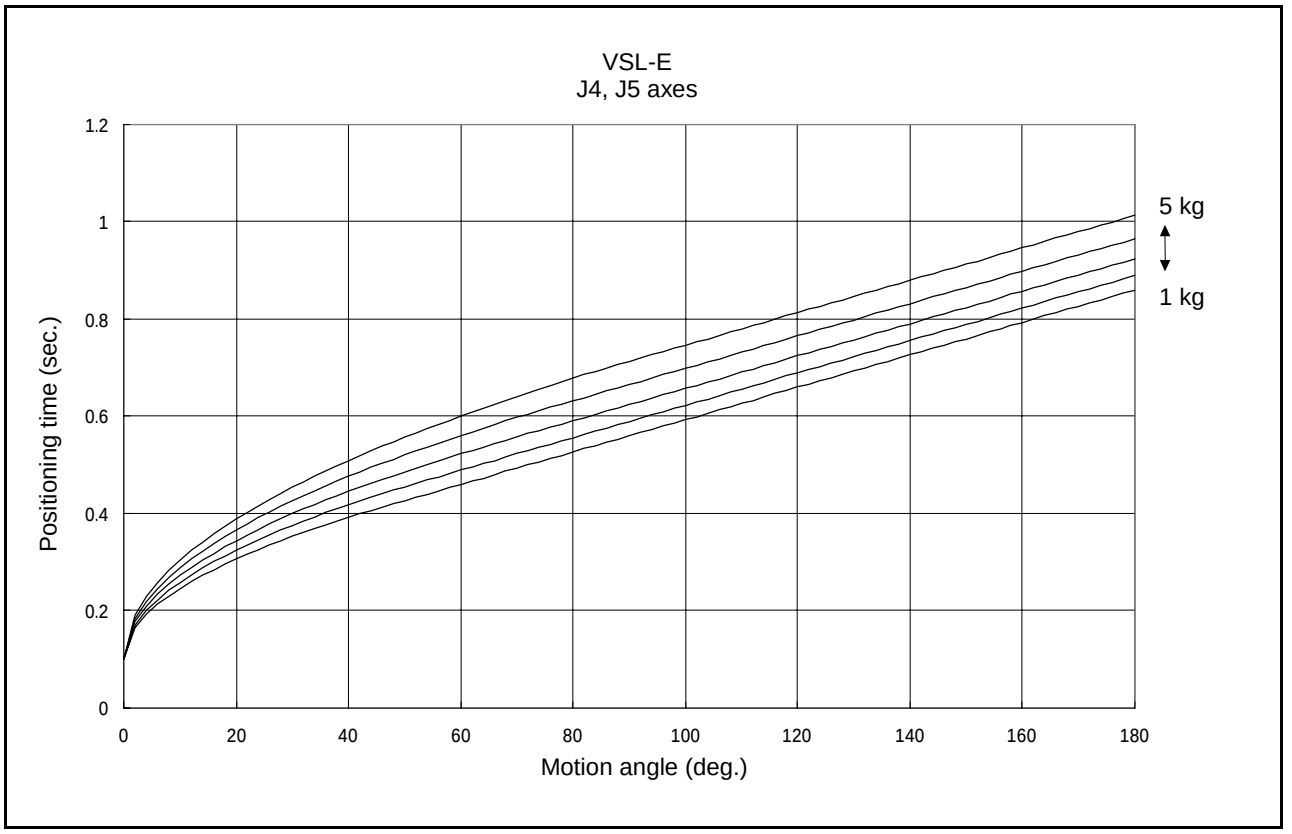


Figure 1-40 J4, J5 Axes [VS-6577E]

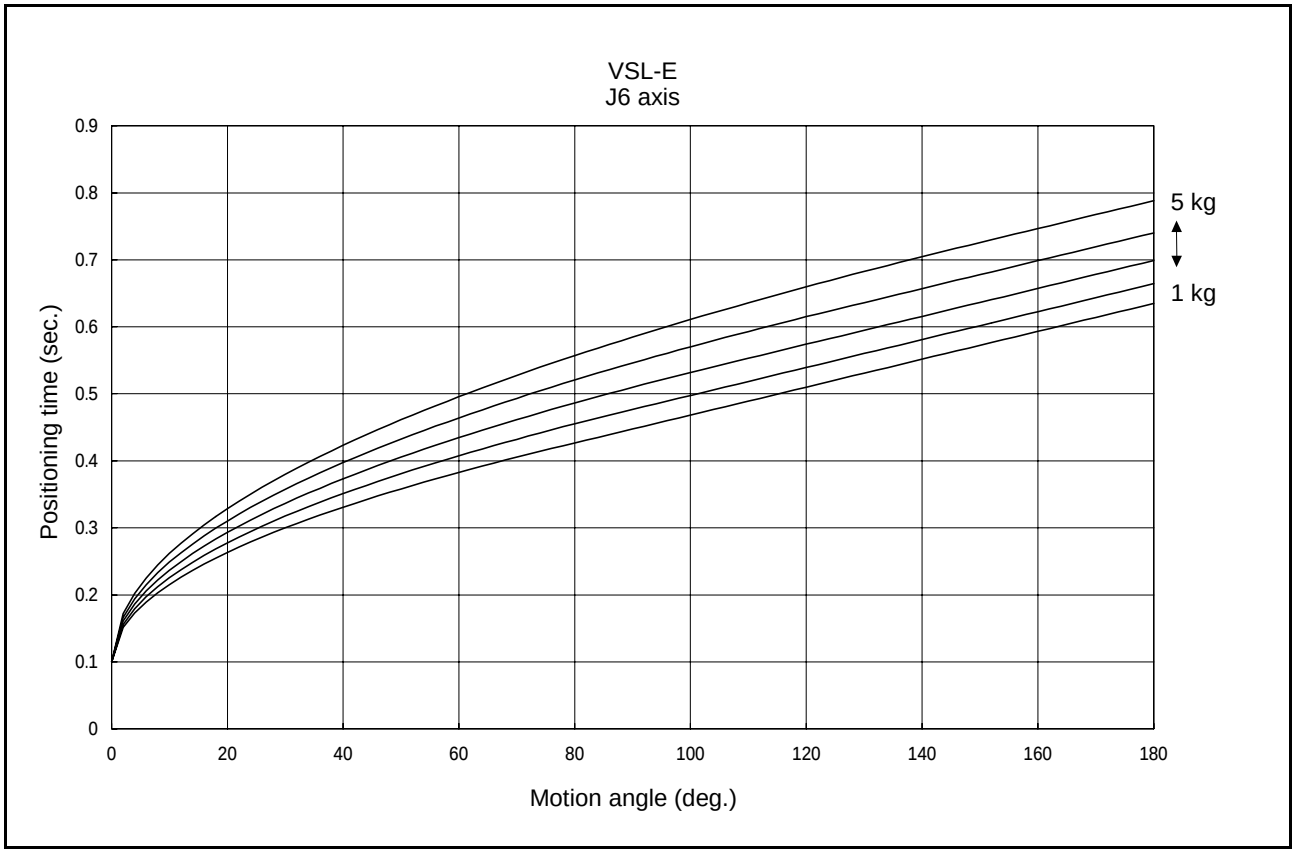


Figure 1-41 J6 Axis [VS-6577E]

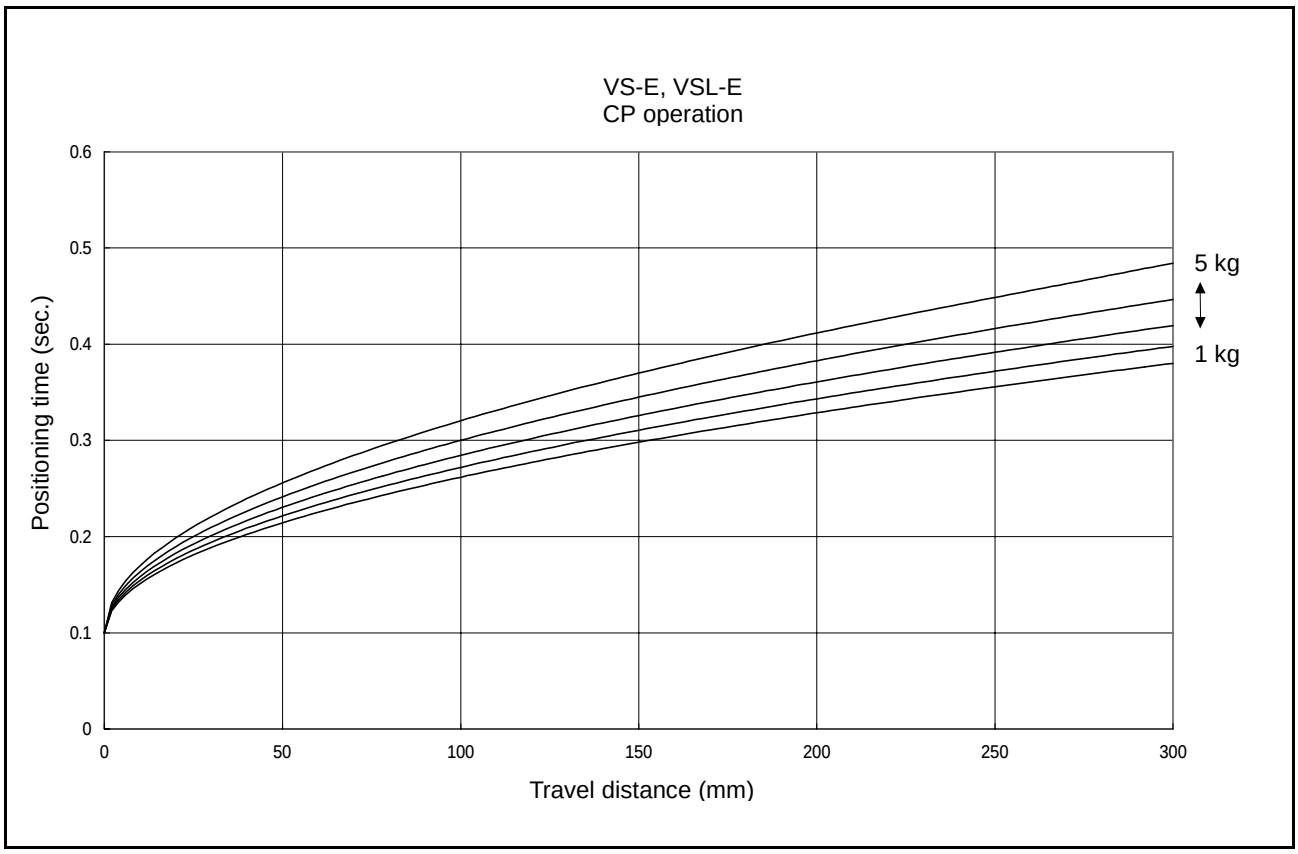
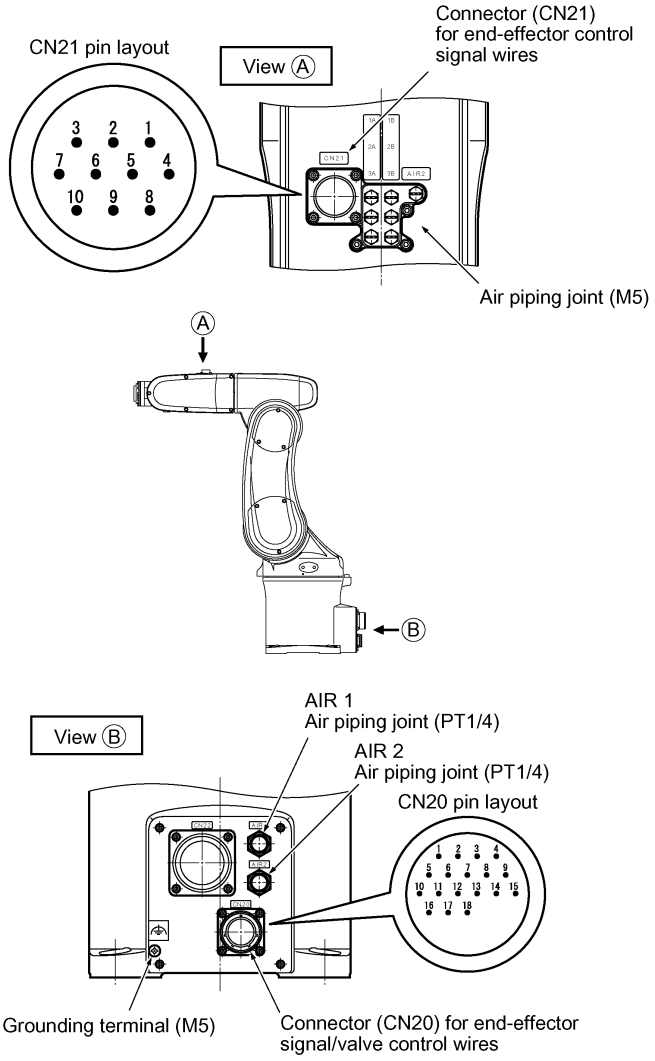


Figure 1-42 CP Operation [VS-6577E]

[4] Air Piping and Signal Wiring

The VS-E series is equipped with 7 air pipes for air chuck, 10 signal lines, and 3 solenoid valves in it. The air piping and signal wiring of the VS-E series are shown in Figure 1-43.

(1) VS-6556E(-B)/VS-6577E(-B)



Valve Symbols and Air Intake/Exhaust States
(1A and 1B are piping joint symbols.)

Air piping joint			Valve signal		
	Air intake	Exhaust	Solenoid valve	Solenoid A	Solenoid B
AIR1	1A	1B	1	ON	OFF
	1B	1A	1	OFF	ON
	2A	2B	2	ON	OFF
	2B	2A	2	OFF	ON
	3A	3B	3	ON	OFF
	3B	3A	3	OFF	ON
AIR2					

CN20 Pin Assignment

For controller I/O unit, NPN type (source IN, sink OUT)

CN20 pin No.	Used for:
12	+24V
13	Solenoid 1A (solenoid valve 1)
14	Solenoid 1B (solenoid valve 1)
15	Solenoid 2A (solenoid valve 2)
16	Solenoid 2B (solenoid valve 2)
17	Solenoid 3A (solenoid valve 3)
18	Solenoid 3B (solenoid valve 3)

For controller I/O unit, PNP type (sink IN, source OUT)

CN20 pin No.	Used for:
12	0V
13	Solenoid 1A (solenoid valve 1)
14	Solenoid 1B (solenoid valve 1)
15	Solenoid 2A (solenoid valve 2)
16	Solenoid 2B (solenoid valve 2)
17	Solenoid 3A (solenoid valve 3)
18	Solenoid 3B (solenoid valve 3)

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.

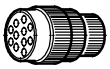
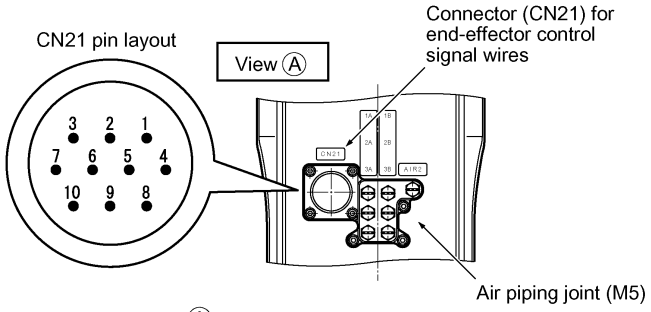
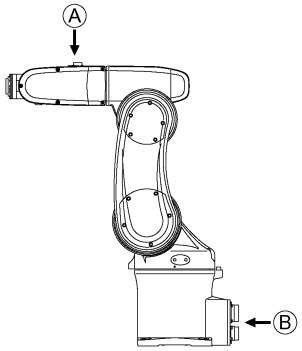
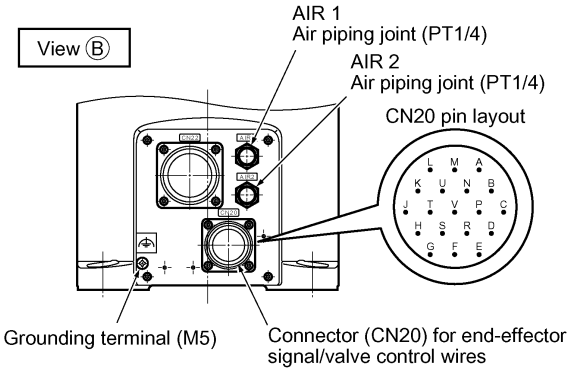
Connector set part No.	Part No.	Model and part name	Appearance
410889-0030	410887-0170 (for CN20)	SRCN6A25-24S (round type connector) (Japan Aviation Electronics Industry)	
	410877-0180 (for CN21)	JMLP1610M (L type plug connector) (Dai-ichi Electronic Industry)	

Figure 1-43 (a) Air Piping and Signal Wiring [VS-6556E(-B)/VS-6577E(-B)]

(2) VS-6556E-(B)W/VS-6577E-(B)W







Valve Symbols and Air Intake/Exhaust States
(1A and 1B are piping joint symbols.)

Air piping joint			Valve signal		
	Air intake	Exhaust	Solenoid valve	Solenoid	
				A	B
AIR1	1A	1B	1	ON	OFF
	1B	1A	1	OFF	ON
	2A	2B	2	ON	OFF
	2B	2A	2	OFF	ON
	3A	3B	3	ON	OFF
	3B	3A	3	OFF	ON
AIR2					

CN20 Pin Assignment

For controller I/O unit, NPN type (source IN, sink OUT)

CN20 pin No.	Used for:
M	+24V
N	Solenoid 1A (solenoid valve 1)
P	Solenoid 1B (solenoid valve 1)
R	Solenoid 2A (solenoid valve 2)
S	Solenoid 2B (solenoid valve 2)
T	Solenoid 3A (solenoid valve 3)
U	Solenoid 3B (solenoid valve 3)

For controller I/O unit, PNP type (sink IN, source OUT)

CN20 pin No.	Used for:
M	0V
N	Solenoid 1A (solenoid valve 1)
P	Solenoid 1B (solenoid valve 1)
R	Solenoid 2A (solenoid valve 2)
S	Solenoid 2B (solenoid valve 2)
T	Solenoid 3A (solenoid valve 3)
U	Solenoid 3B (solenoid valve 3)

Note 1 : Pins A to K on CN20 and pins #1 to #10 on CN21 are connected with each other as shown below. The allowable current per line is 1 A.

CN20	A	B	C	D	E	F	G	H	J	K
CN21	1	2	3	4	5	6	7	8	9	10

Note 2 : Use the attached connector sets for CN20 and CN21.

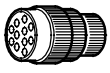
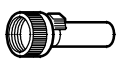
Connector set part No.	Part No.	Model and part name	Appearance
410889-0010	410877-0120 (for CN20)	H/M3106AZZ-14S (straight plug) (Hirose Electric)	
	410877-0130 (for CN20)	H/MS3057-12A (cord clamp) (Hirose Electric)	Applicable wire diameter ϕ11.4 to 15.9 
	410877-0140 (for CN20)	H/MS3057-12A1 (cord clamp) (Hirose Electric)	Applicable wire diameter ϕ8 to 11.6
	410877-0070 (for CN21)	EBLP1610M (L type plug connector) (Dai-ichi Electronic Industry)	

Figure 1-43 (b) Air Piping and Signal Wiring [VS-6556E-(B)W/VS-6577E-(B)W]

Table 1-11 Solenoid Valve Specifications (VS-E series)

	Item	Specifications
Valve	Switching system	2-position double
	Applicable fluid	Air
	Operating system	Pilot type
	Effective cross section (Cv value)	1.2 mm^2
	Lubrication	Oilless
	Operating pressure range	0.1 to 0.7 Mpa
	Response time	15 ms or less (at 0.5 Mpa)
	Maximum operating frequency	10 Hz
	Ambient temperature	-5 to 50°C (No dew condensation allowed. When dry air is used)
Solenoid	Operating voltage	24 V ±10%
	Power consumption (current)	0.5 W (21 mA)
	Surge voltage protection circuit	Zener diode

1.4 Robot Controller Specifications

[1] Specifications

Table 1-12 lists the robot controller specifications.

Table 1-12 Robot Controller Specifications (VS-E series)

Item		Specification
Applicable robot		Small-sized, vertical articulated type (VS-E series)
Model		RC5-VSE6BA
Control system		PTP, CP 3-dimensional linear, 3-dimensional circular
No. of controllable axes		Up to six axes simultaneously
Drive system		All axes: Full-digital AC servo
Memory capacity		1.25 MB (equivalent to 5000 steps, 13,000 points)
Language used		DENSO robot language (conforming to SLIM)
No. of teach programs loadable to the memory		255
Teaching system		1) Remote teaching 2) Numerical input (MDI)
External signals (I/O)	Input signal	20 user open points (PLC 12, hand input 8) + 36 fixed system points
	Output signal	32 user open points (PLC 24, hand output 8) + 33 fixed system points
External communication		RS-232C: 1 line Ethernet: 1 line (option)
Timer function		0.02 to 10 sec.(in units of 1/60 sec.)
Self-diagnosis function		Overrun, servo error, memory error, input error, etc.
Error display		Error codes will be displayed on the external I/O or the operating panel (option). Error messages will be displayed in English on the teach pendant (option).
Power source		3-phase, 200 VAC-15% to 230 VAC+10%, 50/60 Hz, 1.5 kVA Single-phase, 230 VAC-10% to 230 VAC+10%, 50/60 Hz, 1.5 kVA
Environmental conditions (in operation)		Temperature: 0 to 40°C Humidity: 90% RH or less (no condensation allowed)
Degree of protection		IP20
Cables (option)	Robot control cable	Standard: 4 m, 6 m High strength: 6 m, 12 m (selective)
	I/O cable	8 m, 15 m
	Power supply cable	5 m
Weight		Approx. 17 kg (excluding attached cables)

⚠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 connectors 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.**

[2] Outer Dimensions

Figure 1-44 shows the outer dimensions of the robot controller.

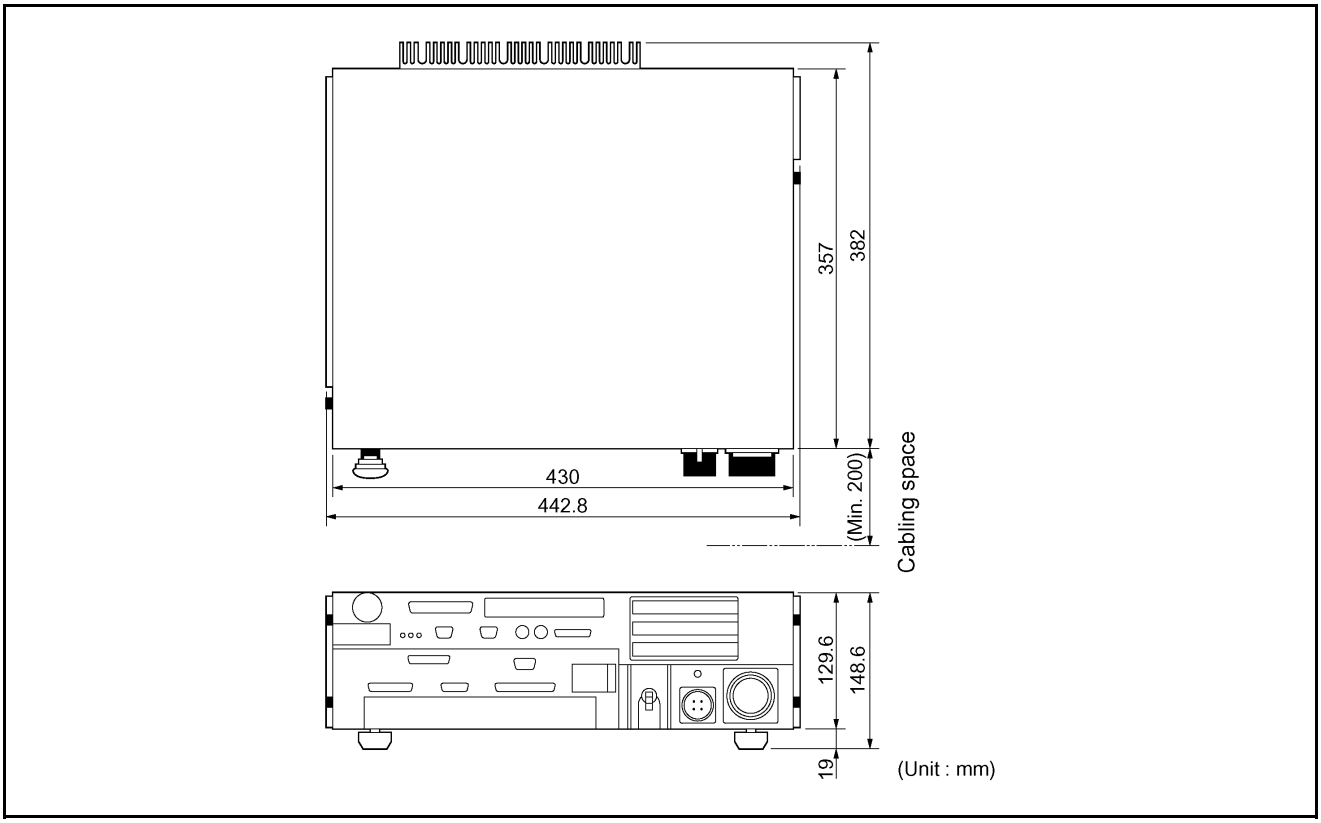


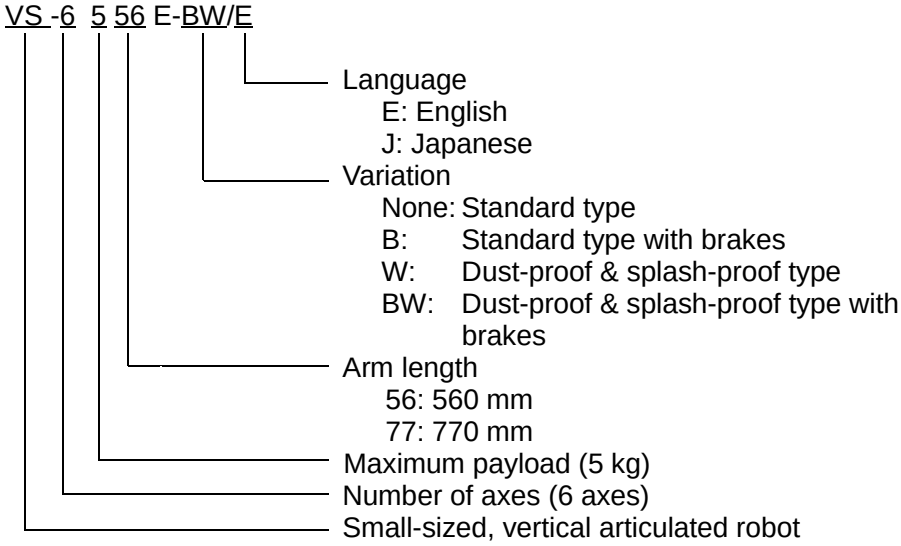
Figure 1-44 Outer Dimensions of Robot Controller (VS-E series)

[3] Controller Setting Table

The controller setting table given in Figure 1-45 is attached to the controller. It shows the parameters that are set before delivery of the robot, as well as the next replacement dates of the memory backup battery and encoder backup battery.

- Parameters (① in Figure 1-45)
  Shows only parameters changed from typical values. Blanks indicate that the typical values are set.
  For further information about parameters, see Chapter 4 "Customizing Your Robot."
- Main software Ver. (② in Figure 1-45)
  Shows the version of the main software for the controller.
- Sub software Ver. (③ in Figure 1-45)
  Shows the version of the control software.
- Battery replacement date (④ in Figure 1-45)
  Shows the next battery replacement date.
- SER No. (⑤ in Figure 1-45)
  Shows the serial number of the robot.
- TYPE (⑥ in Figure 1-45)
  Shows the model of the robot set. Its coding system is described below:

Small-sized, vertical articulated type (VS-E series)



コントローラ設定表/THE SETPRM LIST

注記1.標準値から変更された個所のみ値を示します。空欄のものは標準値が設定されています。
2.パラメータ値を変更した場合は、必ず下表の値の書き直し、または記入をしてください。
Note1.Only the different value from the defaults of the SETPRM are written. The blank means default.
2.Write the new values on this list when you modify the SETPRM values.

① 1 パラメータ/PARAMETER

パラメータ PARAMETER		値 VALUE
正方向ソフトリミット PLIM	1	
	2	
	3	
	4	
	5	
	6	
	7	
	8	
負方向ソフトリミット NLIM	1	
	2	
	3	
	4	
	5	
	6	
	7	
	8	
RANG	1	
	2	
	3	
	4	
	5	
	6	
	7	
	8	
I/Oモード I/O MODE		

② メインソフト Ver. MAIN SOFTWARE Ver.

③ サブソフト Ver. SUB SOFTWARE Ver.

④ 電池交換日 DATE OF RENEWING BAT.

⑤ SERIAL No.

⑥ TYPE

2 サブアッセンブリ/SUBASSEMBLY

名称 BOARD	型式 BOARD TYPE	備考 REMARK
メインボード MAIN BOARD	RP227	
I/Oボード I/O BOARD	RP228, 229	
電源ボード POWER SUPPLY BOARD	RP214A,B	
ハーネスボード HARNESS BOARD	RP231	
NFボード NF BOARD	RP235A	
コンパクトABSボード C-ABS BOARD	RP240A	
ブレーキリレーボード BRAKE RELAY BOARD	RP242	
回生抵抗ボード RESISTER BOARD	RP243	
IPMボード (L) IPM BOARD (L)	RP232	
IPMボード (M) IPM BOARD (M)	RP232	
IPMボード (S) IPM BOARD (S)	RP232	
IPMボード (SS) IPM BOARD (SS)	RP232	
拡張ボード1 EXTENSION BOARD 1		
拡張ボード2 EXTENSION BOARD 2		
拡張ボード3 EXTENSION BOARD 3		
メモリボード MEMORY BOARD	RP234	
FD		

3 その他の変更点/OTHER MODIFICATIONS

Figure 1-45 Controller Setting Table

1.5 Warranty

DENSO manufactures robots 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 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 by DENSO;

(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 by DENSO, 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.

Chapter 2

Installing Robot Components

This chapter describes procedures and precautions for transporting the robot during installation and for designing end-effectors.

For safe operation of the robot, read "SAFETY PRECAUTIONS, 2. Installation Precautions."

Contents

Installing Robot Components

2.1 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.

2.1.1 Installation Environments

■ Standard Type

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.

■ Dust-proof, Splash-proof Type

The robot is IP54-equivalent dust-proof and splash-proof, but it is not designed to withstand explosions. (The wrist of the VM-D-W/VS-E-W is 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 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 other than DENSO authorized oil is in use, or

NOTE: DENSO authorized oil: Yushiron Oil No. 4C (non-soluble)

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

2.1.2 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.

2.1.3 Vibration

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

2.1.4 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** **Configured as a set, the robot unit and robot controller are given the same serial number. For the position of the serial number, see "1.3 [2] Outer Dimensions and Workable Space of the Robot Unit" and "1.4 [2] Outer Dimensions."**

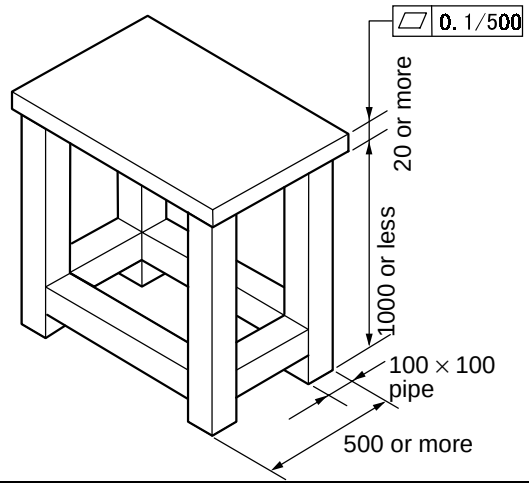
2.1.5 Installation Environment of the Robot Unit

Table 2-1 lists the installation requirements for the robot unit. Prepare a highly rigid mount as shown in Figures 2-1 and 2-2.

> ⚠**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.**

Table 2-1 Installation Requirements for the Robot Unit

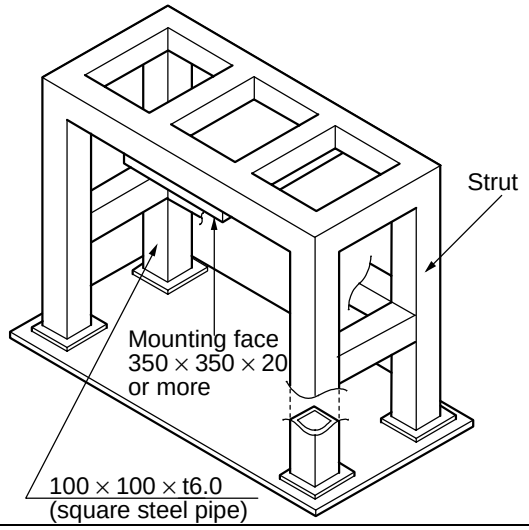
Item	Environments and Conditions	
Flatness of the mount	0.1/500 mm (See Figure 2-1.)	
Rigidity of the mount	Use steel materials. (See Figure 2-1 or 2-2.)	
Installation type	Floor-mount or Overhead-mount (In the VS-D series is a model exclusively designed for overhead-mount.)	
Ambient temperature	During operation : 0 to 40°C During storage and transportation : -10 to 60°C	
Humidity	During operation : 90% or less (No dew condensation allowed.) During storage and transportation : 75% or less (No dew condensation allowed.)	
Vibration	During operation : 4.9 m/s^2 (0.5G) or less During storage and transportation : 29.4 m/s^2 (3G) or less	
Safe installation environment	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.	
	Standard type	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.
	Dust-proof, splash-proof type (IP54-equivalent dust-proof and splash-proof structure. The wrist of the VM-D-W/VS-E-W is IP65-equivalent.)	The robot should not be installed in an environment where: • it may likely be submerged in fluid, • there are any grinding or machining chips or shavings, or • any machining oil other than DENSO authorized Yushiron Oil No. 4C (non-soluble) is in use.
Working space, etc.	• Sufficient service space must be available for inspection and disassembly. • Keep wiring space (230 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.	
Installation conditions	Grounding resistance: 100 Ω or less	



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.

Figure 2-1 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.

Figure 2-2 Robot Mount Example for Overhead-mount

2.2 Installing the Robot Unit

■ VS-E Series

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

[1] Transporting the Robot Unit

(1) Precautions in transporting the robot

The VS-E series weighs approximately 30 kg. Use a crane suitable for the robot weight.

Have at least two workers handle this job.

Workers should wear helmets, safety shoes, and gloves during transport.

⚠Caution Pass the hoisting wires through the specified eyebolts as illustrated below. Passing them through other sections may drop the robot unit, resulting in a broken robot or bodily injuries.

Do not hold the first arm, elbow, either side of the 2nd arm, 2nd-axis cover, or 3rd-axis cover, or apply force to any of them.

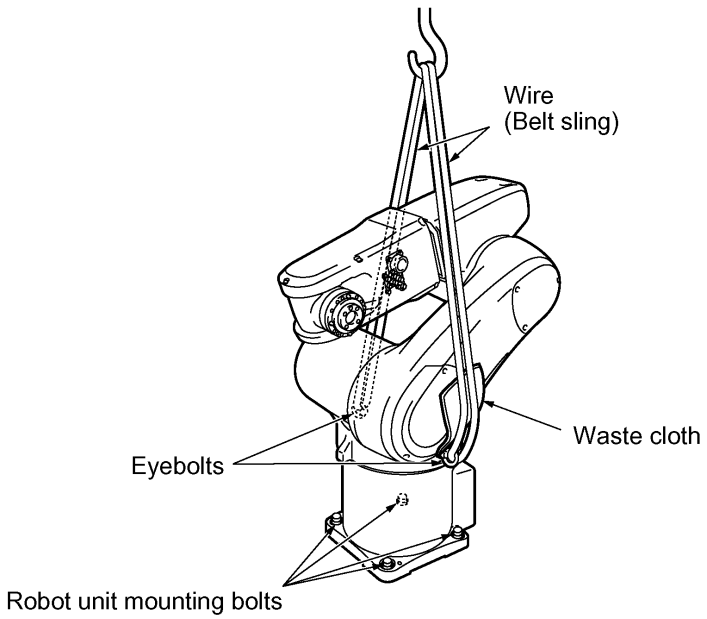
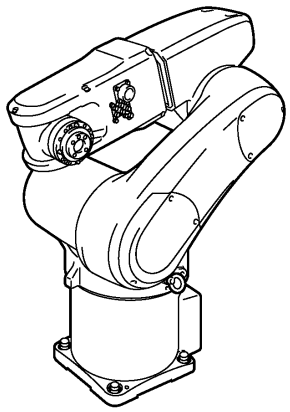


Figure 2-30 Hoisting Points for Transportation (VS-E series)

(2) Transporting the robot unit

<table>
<tr><th>No.</th><th>Procedure</th><th>Explanatory Illustration</th></tr>
<tr><td>1</td><td>Before transportation, set the robot in a transport position as shown at right by manually moving the second, third and fourth axes.

When unpacked first, the robot is in the transport position, so this job is not required.</td><td> 
Figure 2-31 Transport Position

<table><tr><th>Axis</th><th>Angle</th></tr><tr><td>First axis (J1)</td><td>0°</td></tr><tr><td>Second axis (J2)</td><td>-55°</td></tr><tr><td>Third axis (J3)</td><td>+163°</td></tr><tr><td>Fourth axis (J4)</td><td>-90 °</td></tr><tr><td>Fifth axis (J5)</td><td>-90 °</td></tr></table></td></tr>
<tr><td>2</td><td>Disconnect the robot control cable, air piping and user signal cables from the robot unit.

When the robot unit is first unpacked, this job is not required.</td><td></td></tr>
<tr><td>3</td><td>As shown at right, mount the eyebolts.

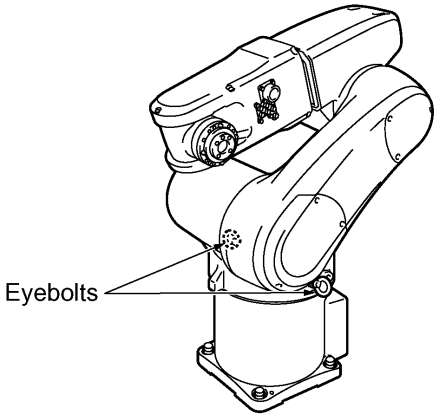
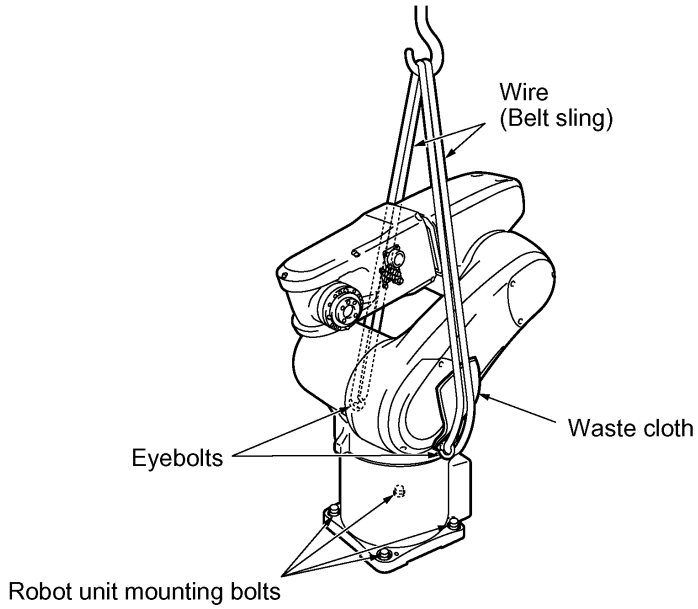
When delivered, the robot unit is packed with eyebolts attached, so this job is not required.</td><td> 

Figure 2-32 Mounting Eyebolts</td></tr>
</table>

No.	Procedure	Explanatory Illustration
4	As shown at right, place a waste cloth on the second arm and pass the wire through the two eyebolts.	 **Figure 2-33 Hoisting the Robot Unit**
5	Worker A: Remove the four bolts while supporting the robot unit to prevent it from getting overturned.	
6	Worker B: Operate the crane and move the robot unit to the target site.	
7	Worker B: Put the robot unit down in the target position. Worker A: Temporarily secure the robot unit with four bolts.	
8	Secure the robot unit according to the instructions in "[2] Installing the Robot Unit" on the next page.	
9	Remove the eyebolts from the robot unit.	

⚠Caution
(1) Before transporting the robot, check that the path to the target position is free of obstacles.
(2) Before running the robot unit, be sure to remove the eyebolts. Otherwise, the robot arm will strike against those eyebolts.

[2] Installing the Robot Unit

(1) Drill four bolt holes (M10) 20-mm deep or more and two knock pin holes (ϕ4H7 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 dimensions shown 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.

When transporting the robot unit, follow the instructions given in "[1] Transporting the Robot Unit."

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

· Bolt: M10 × 30 mm (strength class: 12.9)
· Tightening torque: 70 ±14 Nm

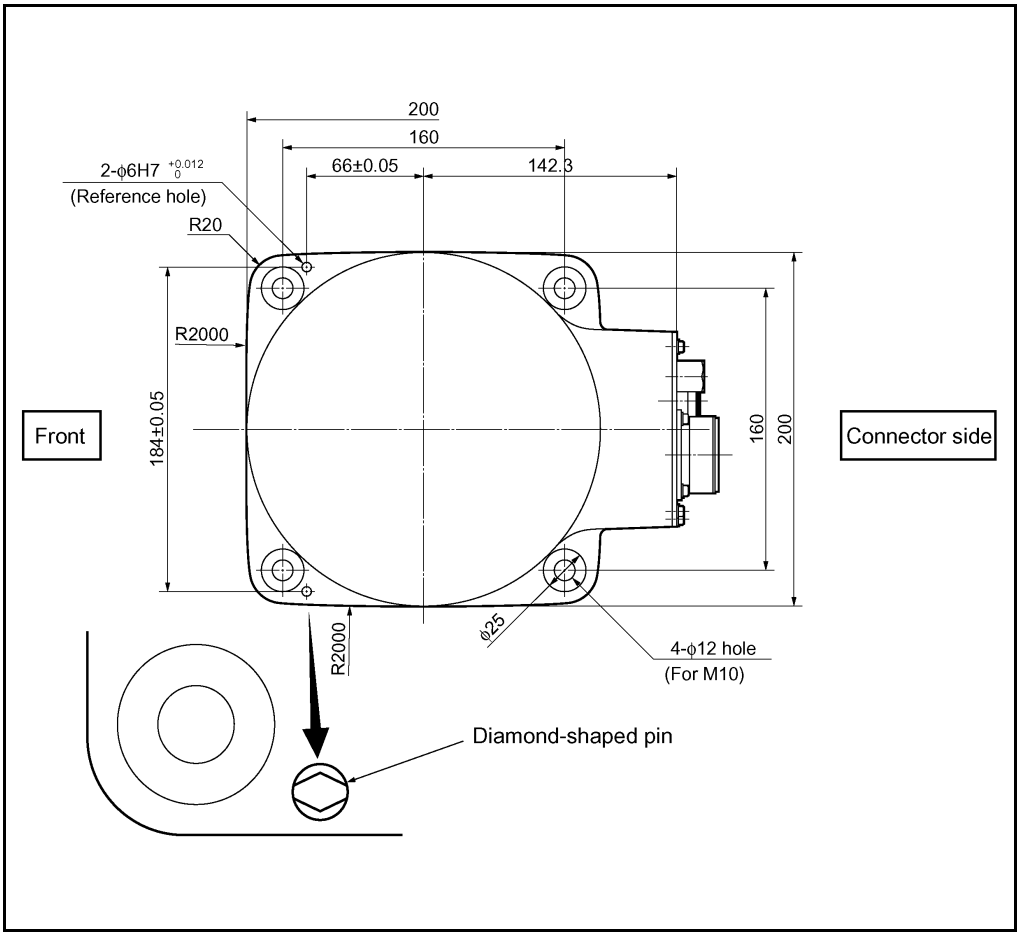


Figure 2-34 Bolt Positions for Securing the Robot Unit (VS-E series)

[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.

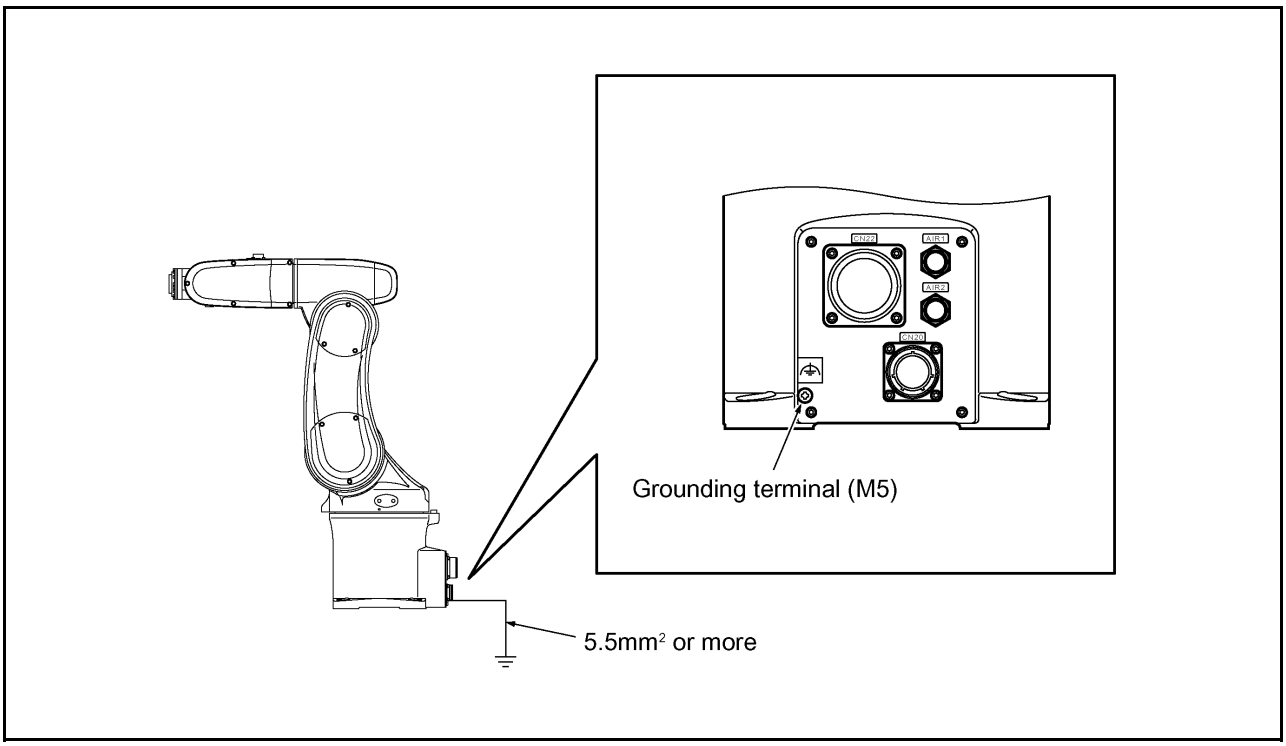


Figure 2-35 Grounding the Robot Unit (VS-E series)

2.3 Installing the Robot Controller

Before installing the robot controller to the target position, you need to secure the robot controller to the controller mounting panel as described in Subsection 2.3.1.

The robot controller supported by the mounting panel may be either stand-alone or wall-mounted.

> ⚠**Caution** **When using the robot controller in any environment where there is mist, put the controller in an optional robot controller protective box. The robot controller is not dust-proof, splash-proof, or explosion-proof.**

2.3.1 Securing the Robot Controller to the Controller Mounting Panel

(1) Figure 2-36 shows the bottom view of the robot controller. Marked with "○," the M4-nut welded holes may be used for securing the robot controller to the mounting panel.

(2) Prepare a mounting panel large enough to mount the robot controller. Secure the robot controller to the mounting panel at six nut-welded holes marked with "○" in Figure 2-36, using six M4 screws.

> ⚠**Caution (1)** **The controller mounting screws must not be more than the thickness of the mounting panel plus 5 mm in length. If they exceed 5 mm, the nut welded holes may be damaged.**
>
> **(2)** **Fix the robot controller at all of the six nut-welded holes.**

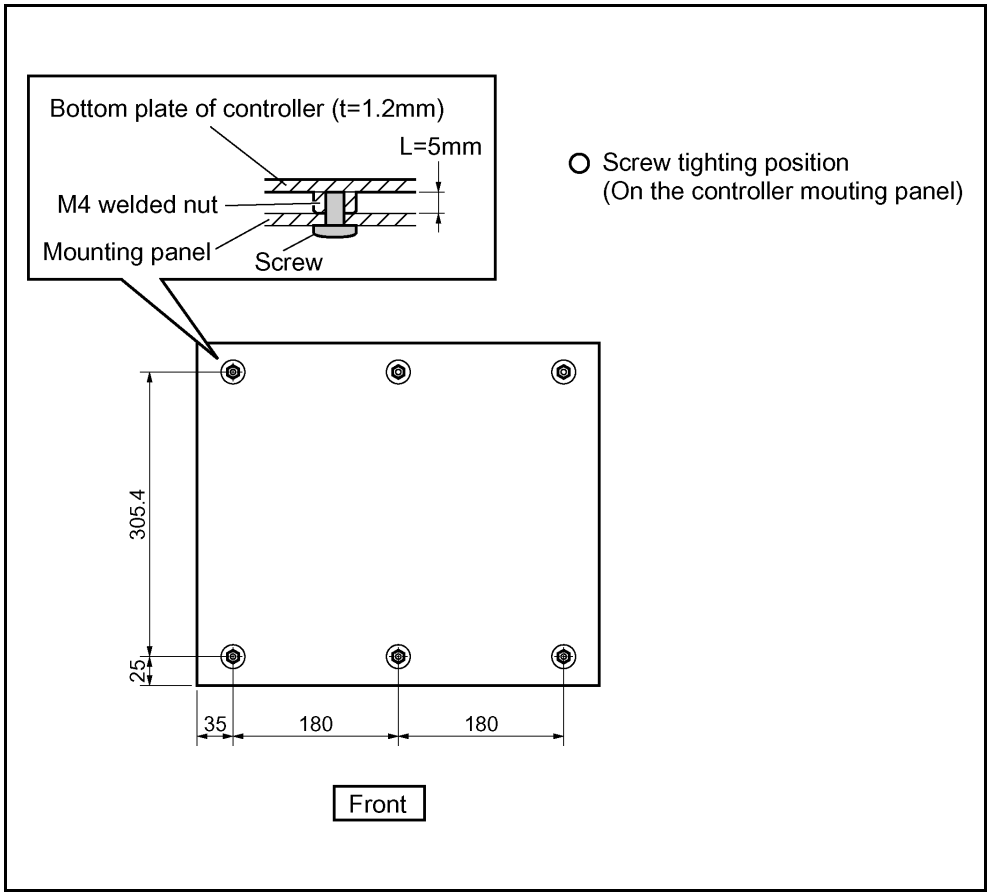


Figure 2-36 Location of Mounting Screw Holes (on the bottom of the robot controller)

2.3.2 Installing the Robot Controller

The robot controller may be installed stand-alone or on the wall.

[1] Stand-alone

Install the robot controller as shown in Figure 2-37.

⚠Caution Do not place anything within 200 mm from the air inlet and air outlet of the robot controller.

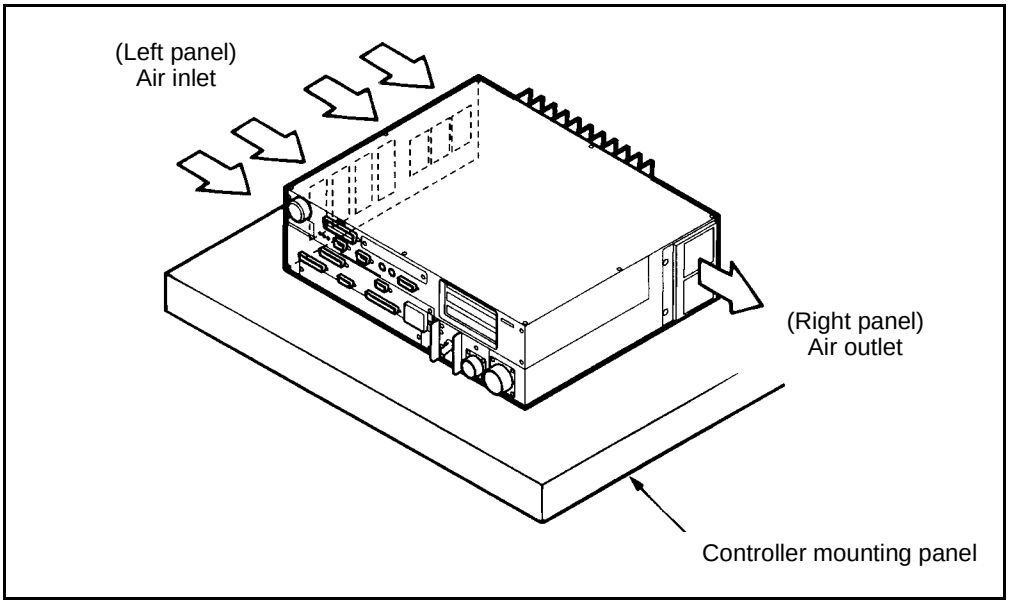


Figure 2-37 Stand-alone Installation (VS-E series)

[2] Wall-mounted

Install the robot controller as shown in Figure 2-38.

⚠Caution Do not place anything within 200 mm from the air inlet and air outlet on the robot controller.

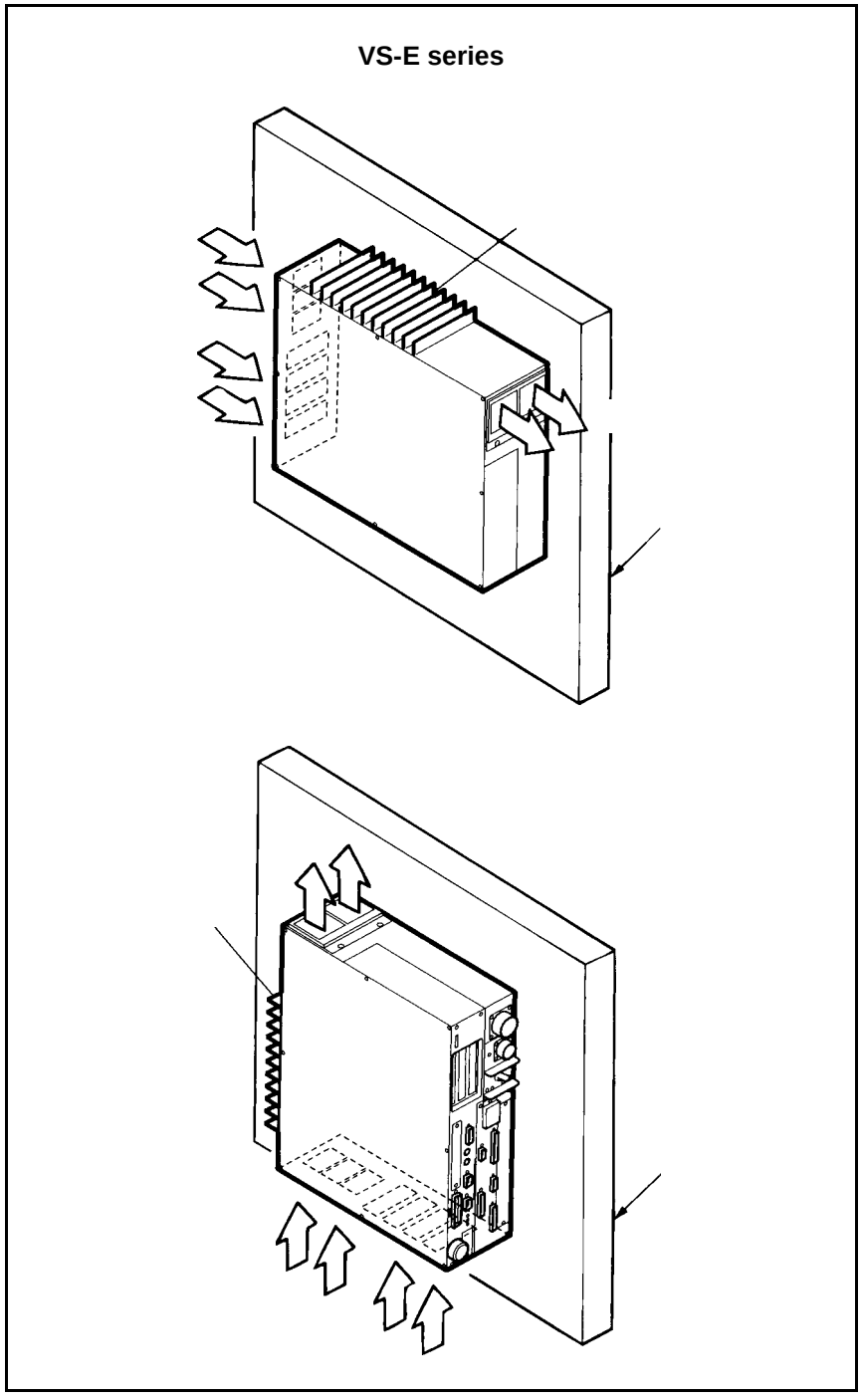


Figure 2-38 Wall-mounted Installation

2.4 Precautions When Designing the End-effectors

■ VS-E Series

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 (5 kg)

(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 range shown in Figure 2-43.

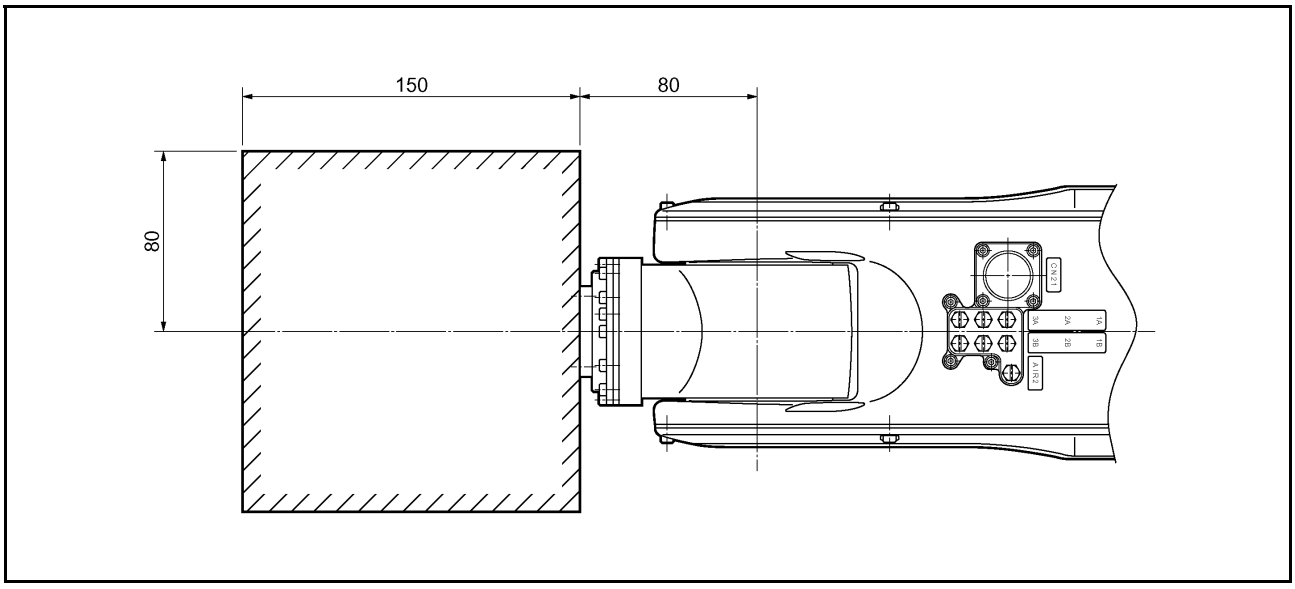


Figure 2-43 Allowable Range of Center of Gravity Position of End-effector (VS-E series)

(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.

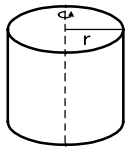
Moment of inertia around J4, J5 and J6 of end-effector (incl. mass of workpiece) ≤ Max. allowable moment of inertia

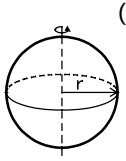
① Max. allowable moment of inertia around J4 and J5: 0.295 kgm²

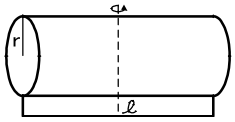
② Max. allowable moment of inertia around J6: 0.045 kgm²

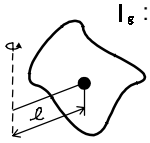
When calculating the moment of inertia around J4, J5 and J6 of the end-effector, use the formulas given in Table 2-4 and Figure 2-44.

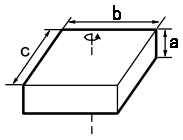
Table 2-4 Moment-of-Inertia Formulas (VS-E series)

<table>
<tr>
<td>1. Cylinder (1)
(Axis of rotation = Center axis)
 

$I = \frac{mr^2}{2}$</td>
<td>4. Sphere
(Axis of rotation = Center axis)
 

$I = \frac{2mr^2}{5}$</td>
</tr>
<tr>
<td>2. Cylinder (2)
(The axis of rotation passes through the center of gravity.)
 

$I = \frac{m}{4}\left(r^2 + \frac{\ell^2}{3}\right)$</td>
<td>5. Center of gravity not on the axis of rotation
 

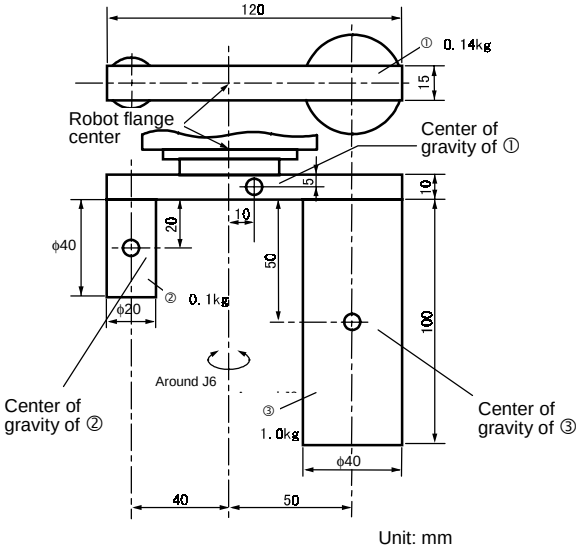
I_g : Inertia moment around center of gravity [kgm²]
$I = I_g + m\ell^2$</td>
</tr>
<tr>
<td>3. Rectangular parallelepiped
(The axis of rotation passes through the center of gravity.)
 

$I = \frac{m}{12}(b^2 + c^2)$</td>
<td>I: Moment of inertia [kgm²]
m: Mass [kg]
r: Radius [m]
b, c, ℓ: Length [m]</td>
</tr>
</table>

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 Table 2-4)

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

Moment of inertia around J6 of ②: I_2 (from 1 and 5 in Table 2-4)

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

Moment of inertia around J6 of ③: I_3 (from 1 and 5 in Table 2-4)

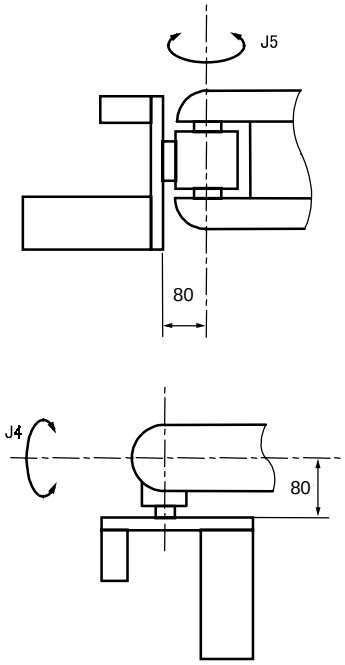
$$I_3 = \frac{1.0 \times 0.02^2}{2} + 1.0 \times 0.05^2$$
$$= 2.7 \times 10^{-3} \ [\mathrm{kgm^2}]$$

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 Table 2-4)

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

Moment of inertia around J4 and J5 of ②: I_2 (from 2 and 5 in Table 2-4)

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

Moment of inertia around J4 and J5 of ③: I_3 (from 2 and 5 in Table 2-4)

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

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

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

Figure 2-44 End-effector Moment of Inertia Calculation Example (VS-E series)