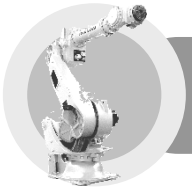
WARNING

THE INSTALLATION SHALL BE MADE BY QUALIFIED INSTALLATION PERSONNEL AND SHOULD CONFORM TO ALL NATIONAL AND LOCAL CODES



Manipulator Maintenance Manual

HC165L/HC200

HYUNDAI ROBOTICS

HYUNDAI ROBOTICS

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Contents

Contents

List of Figures

List of Tables

1
Safety

1.1. Introduction

The main purpose of this chapter is to describe the safety precautions for users and operators who repair and manipulate the industrial robot.

This manual describes safety precautions for robot manipulator and controller, in complies with the safety regulation of EU Machinery Directive 98/37/EC(2006/42/EC) and US OSHA. And the robot manipulator and controller is manufactured to comply with the safety standards EN ISO 10218-1:2011 and ANSI/NFPA 79:2021.

Every operator, who installs, replaces, adjusts, manipulates, maintains, and repairs, must read thoroughly and fully understand the manipulation and maintenance manual, in particular, the special attention must be paid to the WARNING symbol, the most important marking related to the safety.

Installation, replacement, adjustment, manipulation, maintenance, and repair of robot system must be performed by the personnel who was duly trained for these purposes, following the indicated operating procedure.

This company is planning and carrying out the relevant training such as maintenance, repair, and manipulation for the above operations, so robot users make sure that robot operators should get the relevant training. And make sure that the robot handling work should be carried out only by the operators who completed this training course.

Hyundai Robotics user of industrial robot has responsibility to observe the safety regulation related to robot adopted in corresponding countries and responsibility to design, install and operate safety equipment well in order to protect workers who work at robot system.

In high-risk areas concerning robot systems in which robots, tools, and accessories operate, there must be a method of protection to stop the workers or objects from entering the area according to ANSI/NFPA 79:2021.

1.1.1. Cautions

Must observe the following items when transporting, installing, and operating the robot.

- When the robot is transported, installed, or operated, the robot may fall over, get overturned or the arm may fall. Therefore, do not enter the range where the robot may fall over or get overturned or the arm may fall.
- If the pressure of the gas spring decreases, the robot arm may fall, so never go under in the direction where the arm may fall. To prevent the arm from falling when the pressure of the gas spring is excessively reduced, do not perform operation in a direction other than the direction of the origin of axis 2. Move axis 2 to the origin, and then supplement the pressure of the gas spring or replace the gas spring.
- Replace the gas spring every 20,000 hours or when the pressure decreases so fast that the proper working pressure (125 bar‑140 bar) cannot be maintained.
- When transporting or carrying out the robot, do not allow a large impact or vibration to be applied to it. In particular, If there is a large impact or vibration when transporting or carrying out a robot with a tool attached, the arm may slip or have a failure.
- If greases with different specifications are mixed, an abnormal sound may occur, so, do not allow them to be mixed.

1.1.2. General Matters

(1) The contents of the manual may be modified without prior notice, and we do not bear any legal responsibility for errors.
(2) We do not bear any legal responsibility for the occurrence of problems such as an accident or damage to the systems applied to the robot.

The areas for which the robot can be applied and the environment in which it can be used are as follows.

Applicable areas

It is applied to the industrial robot used by installing on the surface of wall or plane (axes addable). It is also appropriate for controlling operation in the dotted section or consecutive section.

Major application is

- Spot welding
- Arc welding
- Cutting
- Handling
- Assembly
- Application such as Sealing
- Palletizing
- Grinding

For the other use than the above emergency application, make a contact with our company to consult on the robot use and possible applications.

Disable environment

Our robot must not be used in a highly explosive environment and the areas contaminated by oil, flammable materials or chemical materials. (Prohibited to be installed and manipulated.)

1.2. Relevant Safety Regulations

The robot is designed as per ISO 10218-1:2011 safety standards for industrial robots, and furthermore in comply with ANSI/NFPA 79:2021 regulations.

1.3. Safety Training

All the personnel who intend to teach, operate or inspect the robot must be trained in an approved robotic operation and safety training course before start-up. The safety training course includes the following details:

- Purpose and functions of safety devices
- Safety procedure to handle the robot
- Performance of robot or the robot system and possible hazards
- Tasks associated with any specific robot applications
- Safety concepts, etc.

1.4. Safety Related Nameplate

1.4.1. Safety Marking

For the purpose of effective safety instructions, the following safety symbols are used in this manual.

Table 1-1 Safety marking

Symbols		Descriptions
Warning		Indicate a highly dangerous situation, meaning that operating or handling in a wrong manner could result in death or serious injury to personnel, or damage to equipment. Attention should be paid to the operation and handling.
Mandatory		Indicate the compulsory measures that should be taken
Prohibited		Indicate the prohibited actions and/or operations that should not be performed.

1.4.2. Safety Nameplate

Identification plates, warning label and safety symbols are attached to the robot and to the inside and outside of control panel. The designation labels and cable Mark for wire harness between the robot and control panel, and the cables inside/outside of control panel are provided.

All of these plates, labels, symbols and marks constitute safety-relevant parts of the robot and the control panel. They must remain attached to the robot manipulator and control panel at their clearly visible positions all the time for the safety and their full performance.

The painted markings on the floor and signs indicating dangerous zones must be clearly distinguished in form, color, and style from other markings on the machine near the robot system or inside the plant facilities where the robot system is installed.

It is forbidden to remove, cover, or paint over by way of spoiling the clearly visible identification plates, warning labels, safety symbols, designation labels and cable marks.

1.5. Definition of Safety Functions

Emergency Stop Functions – IEC 204-1,10,7

There is one emergency stop button on the controller and teach pendant respectively. If necessary, additional emergency buttons can be connected to the robot's safety chain circuit. The emergency stop function, which overrides all other robot controls, can bring the current operation to a halt by cutting off the power supply to the motors of individual axes. This function will also shut down the power supply to other dangerous functions, which are controlled by the robot, to prevent them from being used

Safety Stop Function - EN ISO 10218-1:2011

A safety stop circuit needs to be configured, and, through this circuit, each robot should be connected with the safeguards and interlocks. The robot should have a number of electrical input signals which can be used to connect external safety devices, such as safety gates, safety pads, and safety lamps. These signals allow the robot's safety functions to be activated by all equipment, including peripheral equipment and the robot itself.

Speed Limitation Function - EN ISO 10218-1:2011

In a manual mode, the maximum speed of the robot is limited to 250 mm per second.
The speed limitation applies not only to the TCP(Tool Center Point), but to all parts of manual mode robot. The speed of equipment mounted on the robot should be possibly monitored.

Restricting working Envelope - ANSI/NFPA 79:2021

Operation area of each axis is restricted by soft limit and hardware limit. Axis 1, 2, and 3 can also be restricted by means of mechanical stopper.

Operation Mode Selection - ANSI/NFPA 79:2021

The robot can be operated either in the manual mode or auto mode. In the manual mode, the robot can be operated only by using the teach pendant.

1.6. Installation

1.6.1. Safety Fence

Install safety fence against the possible collision between the robot and workers, so that no worker may approach the robot.

Install safety fence against the possible collision between the robot and workers, so that no worker may approach the robot. When operators or other personnel enter the robot's working envelope by accident, it may cause an accident. Install the safety fence to stop the robot when one, who intends to replace for TIP DRESSING or TIP changing replacement, or to inspect welding equipment, opens the fence gate and approaches the equipment during operation.

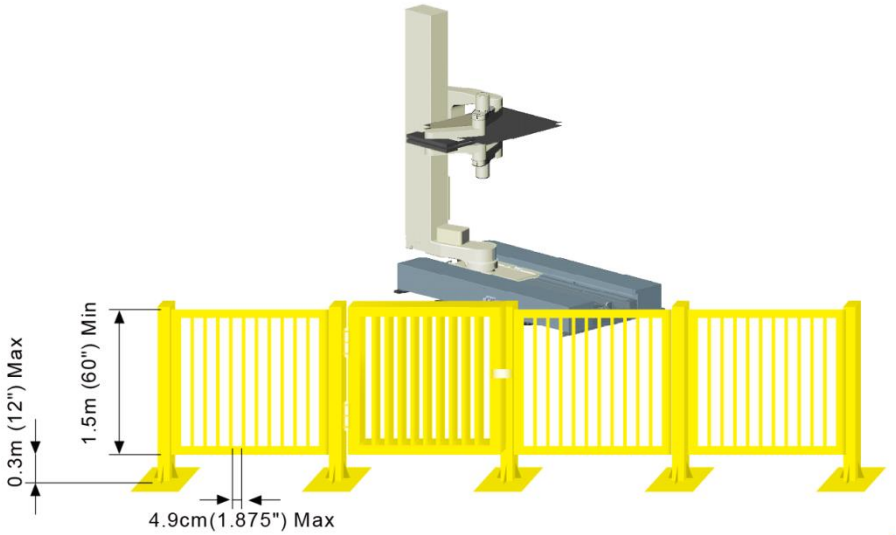


Figure 1.1 Recommended size for safety net and entrance gate (slot type entrance gate)

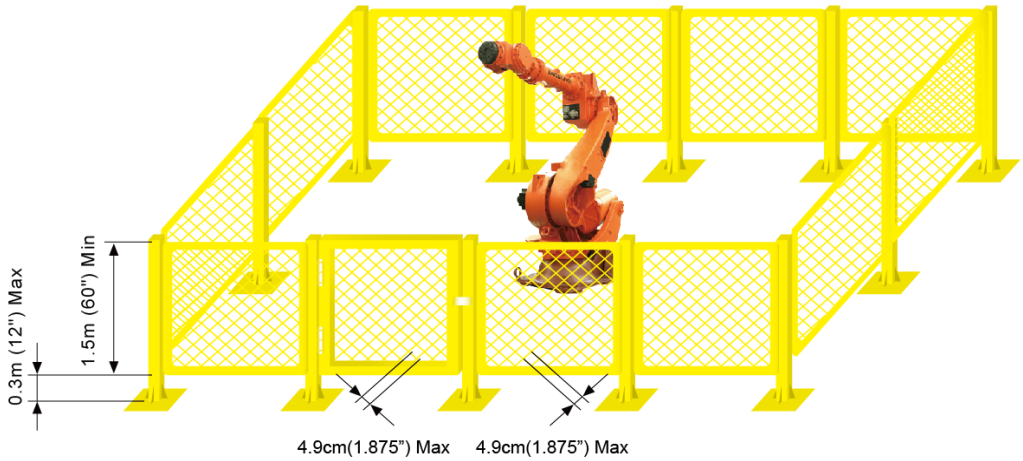


Figure 1.2 Recommended size for safety net and entrance gate (square type entrance gate)

(1) Enough space for safety net should be secured by covering robot operating area so as that workers would not have difficulty in teaching work or repairing work, and the safety net should have solid structure in order that it would not move easily and man cannot enter over easily.

(2) Safety net should be installed by static type in principle, and should not have hazardous parts such as prominence and depression or keen part, etc.

(3) Install the safety fence with an entrance gate, and register the safety plug at the gate so that it does not open unless pulling the plug out. Wiring should be carried out in a way that the robot should be in the operation ready OFF status as well as in the motor OFF status when the safety plug is pulled out or safety net is open.

(4) In order to operate the robot with the safety plug pulled out, wiring should be carried out in a way that will allow the playback to take place at a low speed.

(5) The emergency stop button should be installed at a place where it can be pushed quickly by the operator.

(6) If no safety net is to be installed, devices such as photoelectric switches, and mat switches, should be installed, instead of the safety plug, to cover the overall area within the robot's operation range in a way that the robot can be stopped automatically when a person enters the robot's operation range.

(7) Operation area of robot (hazardous area) should be distinguished by the method like painting on floor.

1.6.2. Placement of Robot & Peripheral Equipment

Please make sure that robot and peripheral equipment should be arranged by following method.

(1) In case of connecting primary power of controller or peripheral devices, please work after checking whether supply power has been deleted. There is a possible danger of electric shock because the high voltage such as 220V and 440V is used as its primary power.

(2) Post a sign [No enter during operation] up the safety fence gate, and inform the operators of its purport.

(3) Arrange such devices as controller, interlock panel, and other manipulation panels to be handled outside of the safety fence.

(4) When installing operation stand, install the emergency stop button on the stand. Make sure that stopping in an emergency situation can be initiated from any place from which the robot is operated.

(5) Make sure that the robot manipulator and the wiring and piping of controller, interlock panel, and timer should not be placed in the way of operator's working range so that they would not be directly stepped on by FORK and LIFT. Otherwise, the operator may suffer electrocution or the wire may suffer disconnection.

(6) Place the controller, interlock panel, and handling stand within the sight of robotic performance. It may cause a major accident to operate the robot while the robot is malfunctioning in an area where the robot’s activity can not be observed, or while the operator is working on it.

(7) Restrict the robot's working envelope by using the soft limits and the mechanical stopper if the necessary working envelope is narrower than the robot’s workable envelope. When the robot is to move beyond the restricted envelop due to abnormal operation, such as the robot being handled in a wrong way, the robot will be stopped automatically in advance thanks to the function that restricts the workable envelop.

(8) During the welding work, spatter could fall down to workers or the workers could be injured by burning, or fire could break out. Install such devices as a glare shield or a cover in the full sight of robot's working envelope.

(9) Make sure that the device indicating the robot's running condition, whether automatic or manual mode, can be noticeable even from a slightly distant location. In the case of automatic start-up, a buzzer or a warning lamp will be useful.

(10) Make sure that there is no projecting part in the robot's peripheral equipment. Cover it, if necessary. It usually could cause an accident if the operator comes in touch with it. And it may cause a major accident when the operator tumbles while being astonished at the sudden movement of the robot.

(11) Don't make the system designed to allow the workers to carry the Work in and out using their hands through the safety fence. It could be a cause of accident associated with compressing or amputating.

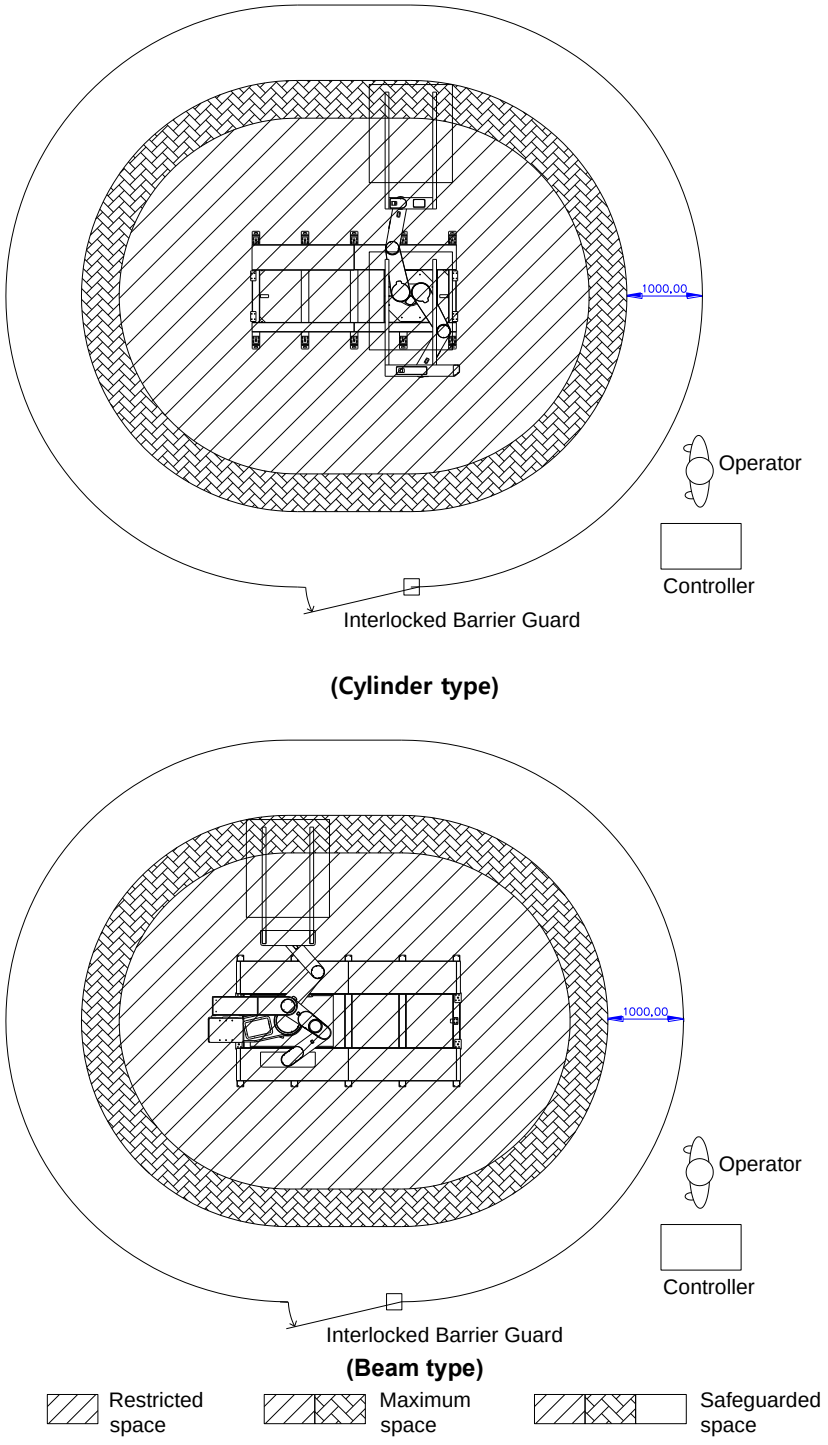


Figure 1.3 Arrangement of LCD robot peripheral devices and workers

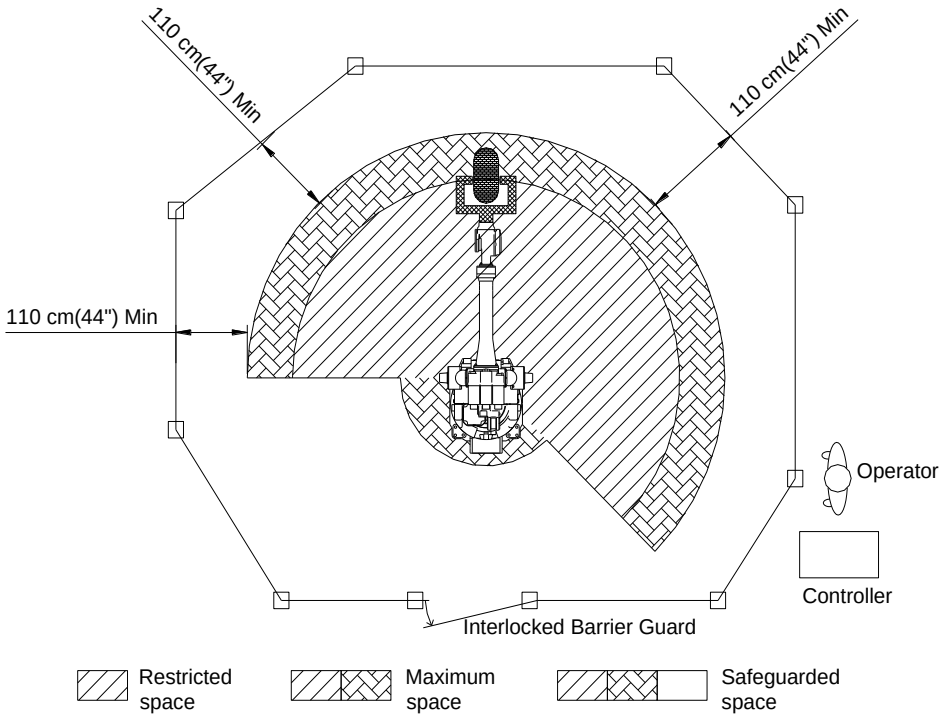


Figure 1.4 Arrangement of general robot peripheral devices and workers

1.6.3. Installing the Robot

Please install the robot in accordance with following method surely.

Install the robot as per the planning and layout which has been previously reviewed and studied for its optimized performance and functionality. In case of poor conditions for robot installation, the serious problems can take place, including error of relative position between robot and workpiece during operation, bad performance quality of robot caused by vibration, shortening lifetime, and cause of serious accidents. Thus, pay attention to the following precautions when installing the robot.

General Safety Precautions

(1) Design and install the robot system properly in compliance with laws, regulations, and safety requirements enable in the country where the robot system is installed.

(2) All the workers for the robot system must have the complete knowledge on the information specified in the application and supplementary manual, and proficiently operate and handle the industrial robot.

(3) Installation workers of robot must follow the safety instructions and apply them to the installation when they face any safety problems.

(4) System provider must ensure that all the circuits utilizing safety functions perfectly perform in a safe way.

(5) Install main power supply to be disconnected from outside of the robot's working envelope.

(6) System provider must ensure that all the circuits utilizing emergency stop function perfectly perform in a safe way.

(7) For the immediate emergency stop, install emergency stop button within the accessible distance for the operator.

Technical Safety Precautions

(1) Eliminate any interference with peripheral equipment considering the dimension and working envelope.

(2) Avoid such place for installing which is directly exposed to the sun, extremely humid, contaminated by oil or chemicals, and containing a large amount of metal powder and explosive gas.

(3) Install at the ambient temperature ranged 0~45℃.

(4) Secure sufficient space for the easier disassembly and maintenance.

(5) Install safety fence with a gate, and prohibit any person from entering the robot's working envelope.

(6) Remove any obstacles out of the robot’s working envelope.

(7) Take a special measure, considering thermodynamics of controller, if the robot is installed near the heating elements or places exposed directly to the sun.

(8) Take a special measure if the robot is installed in a place of abundant dust such as metal powder in the air.

(9) Install the robot not to transmit welding electric current. In other word, insulate SPOT GUN with/from the robot’s wrist.

(10) Grounding is very critical in preventing electric shock and malfunction caused by noise, and thus install as following instructions.

① Install an exclusive grounding terminal using class 3 or higher. (For the input voltage of 400V of higher, use special class 3 or higher.)

② Connect grounding line into the grounding bus-bar inside of the control panel.

③ In case of direct grounding on the floor by anchoring, two-point grounding both by robot manipulator and by controller can produce a “ground loop” and contrariwise cause abnormal operation. In this case, connect the grounding line to the base of robot manipulator and disconnect the second grounding point to the controller. If the robot vibrates even after stopping, double-check the grounding status because the possible main causes could be an incomplete grounding or “ground loop”.

④ In the use of internal transgun(GUN), there is a possible danger of dropping because the primary power cable is directly connected to the spot gun. In this case, directly connect the grounding line to the base of robot manipulator in order to prevent any electric shock and protect the control panel, but do not connect it to the controller.

1.6.4. Space for Robot Installation

Install robot after securing sufficient space for maintaining the robot manipulator, controller, and other peripheral equipment. To install the main body and controller, please secure the above mentioned installation area. Install controller outside of the safety fence in order to monitor the robot manipulator and to operate in a safe way.
When installing, be sure to make it easier to perform the maintenance when opening the Controller door. Secure the available space. The specifications of the controller can change according to the type of the controller. (For more details, please refer to the “Maintenance manual”.)

1.7. Safety Operation for Robot Handling

Follow the safety instructions to prevent any accidents. Don't modify nor ignore safety devices or circuits at any time, and be careful of electric shock.
All the normal operations in an automatic mode must be performed outside of the safety fence. Check the robot's working envelope if anyone is inside before operating.

1.7.1. Safety Precautions for Robot Handling

Please observe following countermeasures because safety is very important for the test operation of the robot.

(1) Do not handle the robot other than such personnel as operators handling the robot and other possible operators and supervisors who were designated as whom duly trained in an approved robotic training course and become familiar enough with the proper operation of the safety and robotic functions.

(2) Be sure to wear helmets, goggles, and safety shoes.

(3) Perform the work in pairs. One person must be ready to press the emergency stop button in an emergency while the other must perform his work quickly but carefully within the robot's working envelope. Always check the escape route before working.

(4) Make sure that there is no one in the working envelope when the power source is on.

(5) Operations such as teaching must be performed outside of the robot's working envelope. However, if the operation is performed within the working envelope after stopping the robot, enter the envelope with safety plug or key switch for converting to automatic mode. Make sure that other operators do not change it into automatic mode by accident. Also, pay close attention to the specific direction of robotic movement in case of abnormal operation and malfunction.

(6) Supervisors should follow the instructions below.
① Be located at a place where you could take an entire view of robot, and commit yourself to monitoring.
② Press the emergency stop button immediately when abnormality is found.
③ Anyone is forbidden to be near the operating area other than those who are engaged in the operation.

(7) In a manual mode, the speed of teaching is limited to 250mm/sec.

(8) In teaching, post a sign [Under Teaching].

(9) Operators must pull the safety plug out, and enter the safety fence with the plug.

(10) Do not use any devices causing noise in and around the teaching area.

(11) Handle the teach pendant button, while checking the teaching point with your naked eyes, and do not handle it just relying on your sense.

(12) It is a repairing part to be prepared for when you buy many sets.

(13) In teaching, check and examine carefully under your feet. In particular, in high teaching for more than 2M, secure a safe zone on which you may step before teaching.

(14) Instructions for any abnormal operations.

① Press immediately the emergency stop button when any abnormal operations are found.
② Be sure to check if the relevant equipment is stopped when checking the abnormality in an emergency stop.
③ In case that the robot stops automatically due to power failure, investigate possible causes and take actions after confirming that the robot completely stops.
④ In case of malfunction of emergency stop devices, immediately disconnect the main power and investigate possible causes to take necessary actions.
⑤ Investigation of the failure must be conducted only by a designated person. For the re-operation after emergency stop, operators must clarify the cause of failure and take necessary actions, and then operate the robot again following the proper procedure.

(15) Write out the operating rules proper to working details and installing location regarding the operation and handling method for the robot, and the necessary actions for robot's any failure. In addition, it is recommended to operate the robot in accordance with the operating rules.

(16) Instructions when the robot stops
Make sure not to approach the robot even when it seems to be stopped. Most accidents occur from a sudden movement of robot which seemed to be stopped when one approaches it. The conditions that the robot stops are as follows.

Table 1-2 State of Robot Stop

No.	State of Robot	Drive Power	Access
1	Pause (Minor failure, Pause switch)	ON	X
2	Emergency stop (Major failure, Emergency stop switch, Safety gate)	OFF	O
3	Input signal standby of peripheral equipment (START INTERLOCK)	ON	X
4	Playback Completion	ON	X
5	Standby	ON	X

Even in the accessible state of robot, be watchful against any possible sudden movement of robot. Make sure to avoid approaching the robot without precautions for emergency under all circumstances.

■ **During temporary halt, the entrance countermeasure same as entrance of teaching work should be considered at the case (nozzle contact, welded part detected, arc error, and so on) of opening entrance gate for simple management against error.**

(17) Clean up any split oil, tools, and impurities in the safety fence after completing robotic operation. Accidents such as conduction may occur in the working envelope contaminated by oil, or scattered tools on its floor. Make a habit of organizing and cleaning things up.

1.7.2. Safety Precautions for Operating Test

Please observe following countermeasures because safety on robot operation is very important.

In case of operating test, errors in design or teaching and inferiority in manufacturing are possibly seen in the entire system such as teaching program, jig, and sequence. Thus, be more careful and safe in case of operating test. Accidents may occur by these combined causes.

(1) Before handling, check the stop buttons and signal functions to stop the robot such as emergency stop button or stop button. And then, check the abnormality - detective movements. Above all, it is the most critical to check all the stop signals. It would be the most important to stop the robot when any possible accidents are predicted.

(2) In case of operating test, start the robot at low speed(approximately 20%~30%) in the variable speed function, and repeat it more than one cycle to check the movements. If any errors are found, immediately correct them. After then, increase in speed (50% → 75% → 100%) gradually, and repeat more than one cycle respectively to check the movements. Operating at high speed from the very beginning may cause a serious accident.

(3) In case of operating test, it is hard to predict what problems would happen. Do not enter the safety fence during operating test. Unexpected accidents are likely to occur because of its low reliability.

1.7.3. Safety Precautions for Automatic Operation

Please observe following countermeasures because safety on robot automatic operation is very important.

(1) While posting a sign [Do Not Enter During Operation] up the safety fence gate, ask the operators not to enter during operation. If the robot stops, you may enter the safety fence under your full understanding of the situation.

(2) Be sure to check if any operators are inside of the safety fence when starting the automatic operation. Operating without checking the presence of operators may cause a personal injury.

(3) Before starting the automatic operation, check and confirm that the program number, step number, mode, and starting selection are in the possible state for automatic operation. If starting with the other programs or steps selected, the robot could move in an unpredicted way, and lead to an accident.

(4) Before starting the automatic operation, check if the robot is properly located to get started. Check whether the program number or step number is identical with the location of robot. Even if it's all identical, accidents are still possible to occur due to an abnormal movement when the robot is differently located.

(5) Be prepared to immediately press the emergency stop button when starting the automatic operation. Immediately press the emergency stop button in case of robot's unexpected movements or emergency.

(6) Be sure to detect any abnormalities by checking the route, condition, or sound of robot movement. Sometimes the robot may be abnormally operated including a sudden break down. However, it will show a certain indication before the break down. Understand the robot's normal condition well in order to catch the symptom in advance.

(7) When any abnormality is detected from the robot, immediately stop and take proper actions on it. Using the robot before any proper actions taken may cause an interruption of produce as well as serious failure leading to a very serious personal injury.

(8) When checking the robot’s movement after the proper actions taken for the abnormality, do not operate the robot with operators inside of the safety fence. Unexpected accidents are possibly to occur because its low reliability may cause another abnormality.

1.8. Safety Precautions for Access to Safety Fence

Please observe following countermeasures because safety on robot automatic operation is very important.

The robot is very heavy and strong, even at low speeds. When entering the safety fence, one must observe the relevant safety regulations of its pertinent country.
The operators always must be aware of the unexpected movements of robot. Robots are able to move fast shortly after being stopped. The operators should know that the robot is able to move in a different route, without any notice, by means of external signals. Thus, when trying to stop the robot during teaching or operating test, one should be able to stop the robot with a teach pendant or control panel.

When entering the working envelope through the safety gate, you must take the teach pendant with yourself so that other people can not operate the robot. Make sure to post up the control panel a sign indicating the state of robot handling.

People must understand the followings when they are to enter the robot's working envelope

(1) Do not enter the working envelope other than teaching person.

(2) Operation set-up mode of controller must be a manual mode in the control panel.

(3) Always wear the approved working suite.(Do not wear a loose clothes as you please)

(4) Do not wear gloves when handling controller.

(5) Do not leave innerwear such as underwear, shirts, or necktie out of the working suite.

(6) Do not wear personal accessories such as big earrings, rings, or necklaces.

(7) Make sure to wear safety shoes, helmet, and goggles and if necessary, wear other self-protective outfit such as safety gloves.

(8) Make sure that the emergency stop circuit is working correctly and in its proper function, turns MOTOR OFF when pressing the emergency stop button in the control panel and teach pendant before handling the robot.

(9) Make your posture face-to-face with the robot manipulator when performing your work.

(10) Follow the predetermined working procedure.

(11) Be prepared for emergency exit or safe place considering that the robot may unexpectedly rush at you.

1.9. Safety Precautions for Maintenance and Repair

1.9.1. Safety Precautions for Controller Maintenance and Repair

Please observe following safety countermeasures on repair and check for robot controller.

(1) Maintenance and repair of the robot must be performed by the personnel who was duly trained in the special maintenance training course and has a good knowledge of maintenance.

(2) Perform your work following the maintenance procedures for controller.

(3) Perform your maintenance and repair in a safe way by securing emergency exit or safe place.

(4) Before the daily maintenance, repair, or changing parts, be sure to power down. In addition, post a warning sign [Do Not Input Power] up the primary power so that other operators may not input power by accident.

(5) When changing parts, be sure to use the specified ones.

(6) When you open the door of controller, you should turn off power, and please start working after 3 minutes.

(7) Please do not touch heat radiating plate of servo AMP and recovery resistance because they are very hot.

(8) After completing maintenance, be sure to close the door completely after checking if tools or other things are still remained in the controller.

1.9.2. Safety Precautions for Robot System & Manipulator Maintenance

Please observe following safety countermeasures on repair and check for robot controller.

(1) Refer to the safety precautions for Controller maintenance and repair.

(2) Perform your maintenance and repair for the robot system and manipulator, following the indicated procedures.

(3) Be sure to disconnect the primary power of controller. Post the warning sign [Do not input power] up the primary power to prevent other workers from connecting the power.

(4) When the manipulator is maintained or inspected, the robot arm may fall or move, causing danger. You must fix the arm before performing the work.

(5) If the pressure of the gas spring decreases, the robot arm may fall, so never go under in the direction where the arm may fall. To prevent the arm from falling when the pressure of the gas spring is excessively reduced, do not perform operation in a direction other than the direction of the origin of axis 2. Move axis 2 to the origin, and then supplement the pressure of the gas spring or replace the gas spring.

1.9.3. Necessary Actions after Maintenance and Repair

Please install the robot in accordance with following method surely.

(1) Check if the cables or parts of controller are properly connected.

(2) After maintenance is completed, carefully check that no tools are left around or inside of the controller and manipulator. Make sure that the door is firmly closed.

(3) Do not turn on the power if any problems or critical failures are detected.

(4) Be sure that there is no one within the working envelope, and that you are in a safe place before turning on the power.

(5) Turn on the main circuit breaker on the control panel.

(6) Check the current position and status of robot.

(7) Operate the manipulator at low speed.

1.10. Safety Functions

1.10.1. Operating a Safety Circuit

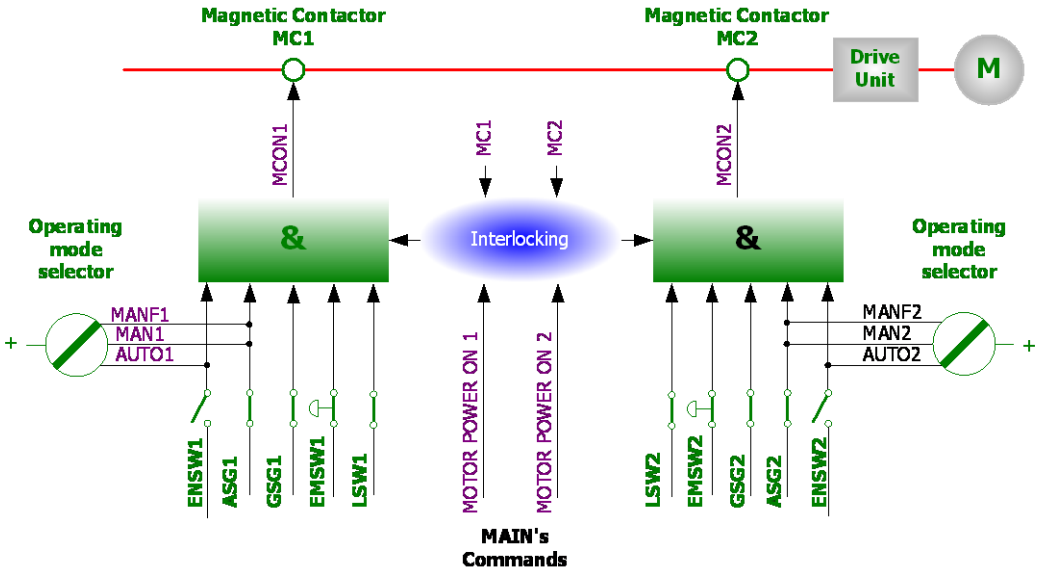


Figure 1.5 Configuration for safety chain

The robot's safety system is based on a two-channel safety circuit that is continuously monitored. If an error is detected, the power supply to the motors is disconnected and the motor brake is applied. To return the robot to MOTOR ON mode, the switches of two-channel circuit must be connected. If one of the two-channel circuit switches shorts, the contactor of motor will be disconnected leading to the application of brake, and finally the robot will be stopped. Furthermore, when safety circuit is disconnected, the interrupting call will be sent automatically to the controller to find out the possible reason for the interruption.

The safety control circuit of operation is based on dual safety electric circuit in which the controller and MOTOR ON mode are operated interactively. In order to be in MOTOR ON mode, the safety circuit consisted of several switches must be all connected. MOTOR ON mode indicates that drive power is supplied to the motors. If one of the contactors is disconnected, the robot will always return to MOTOR OFF mode.
MOTOR OFF mode indicates that drive power is removed from the robot's motors and the brakes are applied. The status of the switches is displayed on the teach pendant. (Refer to the I/O monitoring screen of "SERVICE" menu, 『Operation manual』.)

Safety circuit

The emergency stop buttons on the controller panel and on the teach pendant and external emergency stop buttons are included in the safety circuit of operation. Users may install the safety devices (safety plug, safety stop device for safe place) which are operated in the AUTO mode. In a manual mode, the signals of these safety devices are ignored. You can connect the general safety stop devices that is active in all operating modes. No one can enter the working envelope in an automatic operation mode due to the unconditional operation of the safety devices (door, safety mat, safety plug etc.). These signals are also generated in a manual mode, but the controller will keep the robot operating while ignoring the robot's teaching. In this case, maximum speed of robot is restricted to 250mm/s. Thus, the purpose of this safety stop function is to secure the safe area around the manipulator while one approaches the robot for maintenance and teaching.

When the robot is stopped with the limit switch, change the robot’s position by operating it with the pendant key at the constant setting mode. (Constant setting mode refers to the state of entry into the menu『[F2]: System』 menu)

The safety circuits must never be by-passed, modified or changed in any way.

1.10.2. Emergency stop

An emergency stop should be activated when people or equipment is located at the dangerous area. The emergency stop buttons are located both on the control panel and on the teach pendant.
All safety control devices such as emergency stop buttons on the control panel must be located outside the working envelope and easily accessible at any time.

Status of Emergency stop

When the button is pressed, the robot will operate as follows.
Robot stops immediately in any cases.

- Disconnect the servo system power.
- Motor brake is activated.
- Emergency stop message is displayed on screen.

For the emergency stop, the following two methods can operated simultaneously.

(1) Emergency stop for control panel and teach pendant (Basic)

Above the control and teach pendant console.

(2) Emergency stop of external system

External emergency stop device (button etc.) can be connected to the safety electric circuit in accordance with applied standard for the emergency stop circuit.
(Please refer to system board in “basic configuration of controller”) At this time, the emergency stop must be connected to be “Normal On” and it must be check for proper operation during test run.

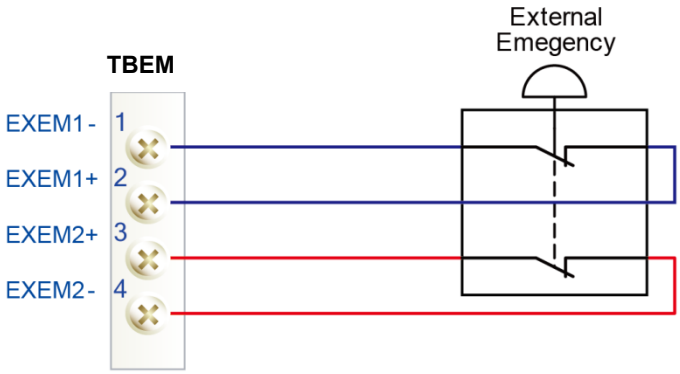


Figure 1.6 Connection with external emergency halt switch through system board terminal block TBEM

1.10.3. Operating Speed

To teach the robot, the operating mode switch must be in a MANUAL mode. Then the maximum speed of robot is limited to 250mm/s.

1.10.4. Connecting the Safety Devices

External safety devices such as light beams, light curtains, safety plug, and safety mats which can be adapted by the system builder execute interlocking the controller by way of connecting with safety circuit within the controller. These devices are used for safety device during execution of normal program in an automatic mode.

1.10.5. Restricting the working Envelope

When the robot is not necessary to reach certain area for specific applications, working envelope of the robot can be limited to secure the sufficient safety working area. This will reduce the damage or loss in case of robot's collision with external safety devices such as safety fence, etc. The movement of axes 1, 2, and 3 of HR, HX, HS and HA can be limited by means of mechanical stopper or electrical limit switches. In this case, the corresponding software limitation parameters must be also changed. If necessary, movement of wrist 3 axes can be restricted, too. Limitation of working envelope for all the axes could be carried out by the user. The robot is delivered to customer as the status of full working envelope setting.

- **Manual mode: Maximum speed is 250mm/s.**
  In a manual mode, by means of worker's selection, workers may enter the safeguard area.

- **Auto mode : The robot can be operated via remote controller.**
  All safety devices such as safety door, safety mats, etc. are activated.
  No one may enter the safety device area of robot.

1.10.6. Monitoring Function

(1) Motor monitoring function s
Motors are protected against overload by means of onboard sensors.

(2) Voltage Monitoring Function
For the protection of, the servo amp module turns off the power switch when the voltage is too low or too high.

1.11. Safety Related to End Effectors

1.11.1. Gripper

(1) When a gripper is used to grip a workpiece, there should be safety precautions for unexpected dropping of the loaded workpiece.

(2) When any end effectors or devices are installed on the robot arm, use the required size and piece of bolt, and securely fasten as per the required torque using torque wrench. Do not use the bolt which has rust or dirt on its surface.

(3) End effector must be designed and manufactured not to exceed the maximum allowable load at the wrist of robot. Even though power or air supply stops, the gripped workpiece must not be dropped from the gripper. In order to remove any risks and problems which may cause personal injury and/or physical damage, the sharp edge and projecting part of end effector must be made dull and smooth.

1.11.2. Tool / Workpiece

(1) It must be possible to replace tools such as milling cutters in a safe manner. Make sure that safety devices are working correctly until the cutters stop rotating.

(2) Tool must be designed to keep in gripping workpiece securely even though a power failure or a control failure takes place. It must be possible to release workpiece from the gripper in a manual mode.

1.11.3. Pneumatic and Hydraulic Systems

(1) The special safety regulations will apply to pneumatic and hydraulic systems.

(2) Since residual energy of pneumatic and hydraulic systems can be still remaining even after the robot stops, particular care and attention must be paid by users. Internal pressure of equipment must be removed whenever starting the repair work for pneumatic and hydraulic systems.

1.12. Liabilities

The robot system has been built in accordance with the latest technical standards and approved safety rules. Nevertheless, the serious accidents such as death or personal injury still may take place due to the collision between the robot system and peripheral equipment.

The robot system must be used by operator who has a full technical knowledge on its designated use and also pay his close attention to the possible dangers and risks involved in its operation. The use of robot system is subject to compliance with these operating instructions and the operation and maintenance manual supplied together with the robot system. The safety related functions of robot system must not be used for any purposes other than safety.

When you use the robot system for any other or additional purposes than its designated usage, you must review whether it is enable in accordance with design criteria. The manufacturers cannot take any responsibility for any damage or loss which resulted from such misuse or improper use. The users shall have the full responsibility for the risks caused by such misuse or improper use. When you use and operate the robot system for its designated use, you must have a good command of all the information contained at these operating instructions as well as the maintenance manual.

The robot system may not be put into operation until it is ensured that the functional machine or plant into which the robot system has been integrated conforms to the specifications of the EU Machinery Directive 98/37/EC(2006/42/EC) and US OSHA.

The following harmonized standards in particular were taken into account with regard to the safety of the robot system.

- ANSI/RIA R15.06-1999
  Industrial Robots and Robot Systems - Safety Requirements
- ANSI/RIA/ISO 10218-1-2007
  Robots for Industrial Environment - Safety Requirements - Part 1 - Robot
- ISO 11161:2007
  Safety of machinery - Integrated manufacturing systems - Basic requirements
- EN ISO 13849-1:2008
  Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design (ISO 13849-1:2006)
- EN 60204-1:2006
  Safety of machinery - Electrical equipment of machines - Part 1: General requirements (IEC 60204-1:2005 (Modified))
- EN ISO 10218-1:2006
  Robots for industrial environments - Safety requirements - Part 1: Robot (ISO 10218-1:2006)

Users must take the full responsibility for any accident caused by their negligence or non-observance of these instructions. The manufacturer will not take any liabilities and responsibilities for any damages or losses caused by the misuse or malfunction of such equipment which is not included in the contract between manufacturer and user and provided by user, or such equipment which is installed around the robot system arbitrarily by the user. User must take the full liabilities and responsibilities for any risks and damages caused by such equipment.

2
Specifications

2.1. Robot Machinery Part

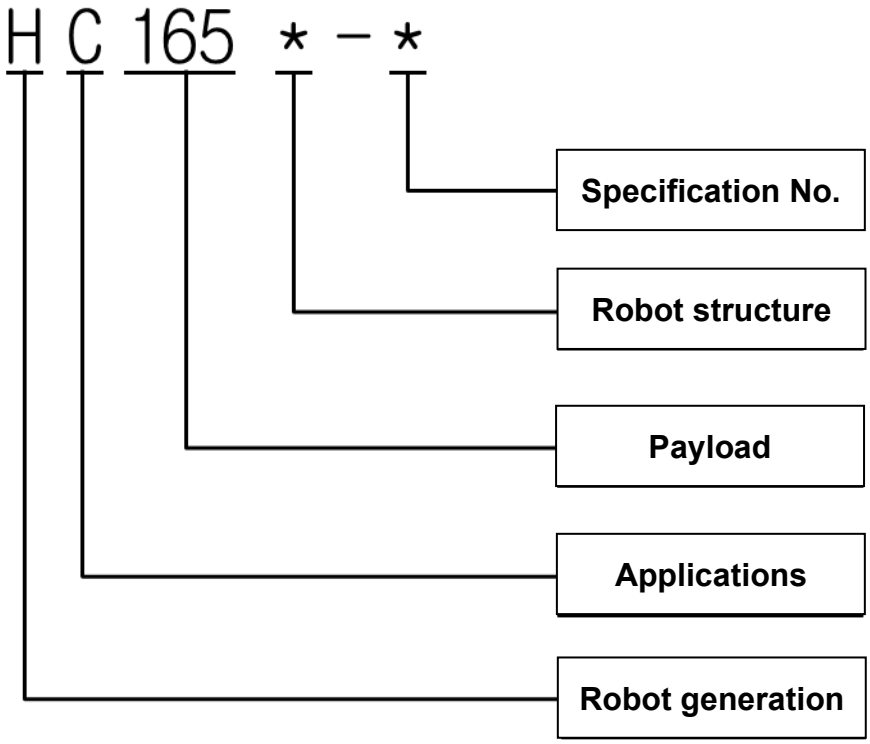


Figure 2.1 Robot Machinery Part

2.2. Location of Robot Identification Plate

The model name, serial number, and manufacturing date of robot are written down in the name plate. The name plate is located at the lower part of the main body (left or right) as shown below.

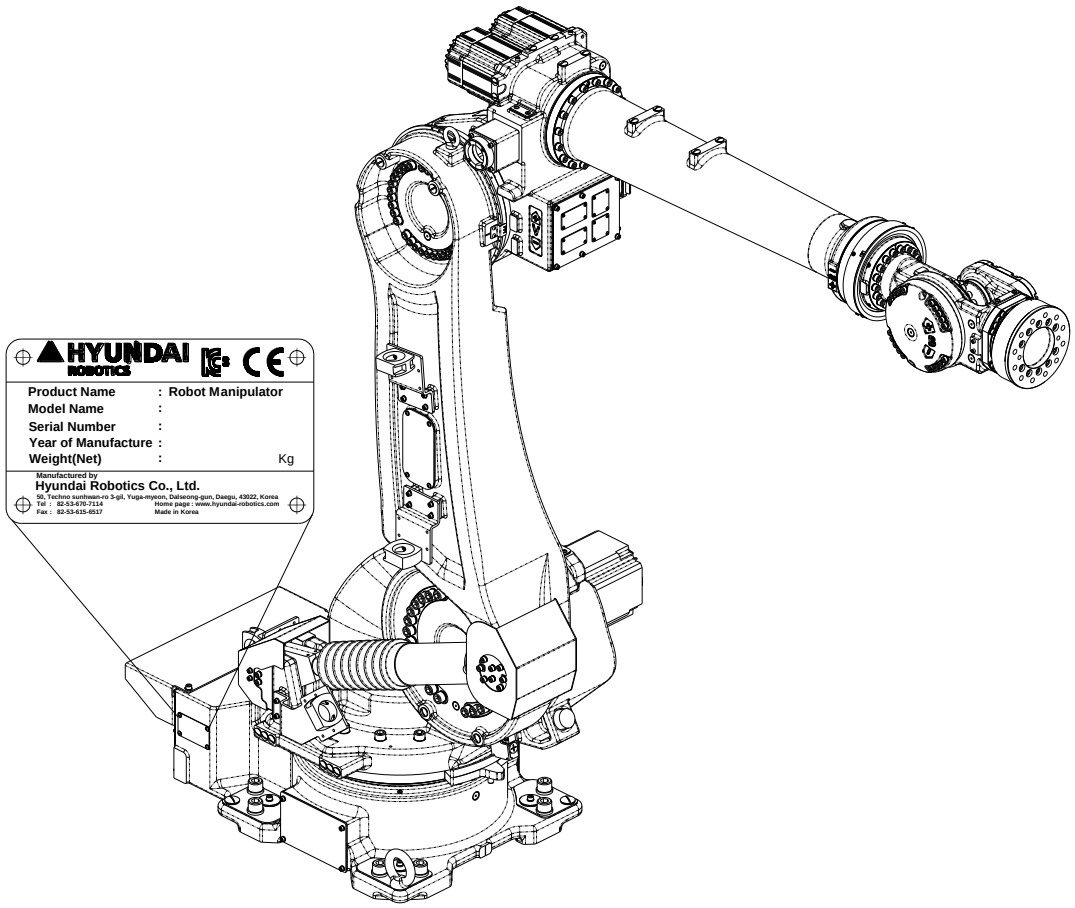


Figure 2.2 The location of identification plate

2.3. Basic Specifications

Table 2-1 Basic Specifications for Models

Item				Specifications	
Model				HC165L	HC200
Maximum Payload				165kg	200kg
Construction				Articulated	
Degree of freedom				6 (6-axes S, H, V, R2,B, R1)	
Drive system				AC servo system	
Installation Type				Floor mount	
Max. Working envelope	Arm	S	Swivel	±3.142 rad (±180°), ±3.107 rad (±178°) LS Option1	
		H	For/Backward	+2.705 ~ 0.175 rad (+155°~ +10°)	
		V	Up/ downward	+3.316 ~ -1.396 rad (+190°~ -80°) +3.316 ~ -1.274 rad (+190°~ -73°) LS Option1	
		H/V	Interference	0.175~3.316 rad (10°~ 280°), 0.279~3.316 rad (17°~ 280°) LS Option1	
	Wrist	R2	Rotation 2	±6.284 rad (±360°)	
		B	Bending	±2.234 rad (±128°)	
		R1	Rotation 1	±6.284 rad (±360°)	
Max. Speed	Arm	S	Swivel	1.833 rad/s (105°/s)	1.745 rad/s (100°/s)
		H	For/Backward	1.658 rad/s (95°/s)	1.571 rad/s (90°/s)
		V	Up/ downward	1.920 rad/s (110°/s)	1.833 rad/s (105°/s)
	Wrist	R2	Rotation 2	3.054 rad/s (175°/s)	2.705 rad/s (155°/s)
		B	Bending	3.504 rad/s (175°/s)	2.705 rad/s (155°/s)
		R1	Rotation 1	4.712 rad/s (270°/s)	4.189 rad/s (240°/s)
Load Capacity				1,617 N (165 kg)	1,960 N (200 kg)
Wrist Torque		R2	Rotation 2	1,030 N·m (105 kgf·m)	1,422 N · m(145 kgf · m)

1 LS Option: Max movable angle when attaching a limit switch to limit the angle.

Item			Specifications	
	B	Bending	1,030 N·m (105 kgf·m)	1,422 N · m(145 kgf · m)
	R1	Rotation 1	490 N·m (50 kgf·m)	770 N · m(79 kgf · m)
Accuracy of position repeatability			±0.3 mm	
Robot's Weight			1,250 kg	1,220 kg
Installation Environment	Clean Class		ISO 14644-A Class 6	
	Ambient Temperature		0 ~ 45℃ (273 ~ 318 K)	
	Relative humidity		20 ~ 85 %RH	
	Vibration		0.5G or less	

2.4. Robot Dimension and Working Envelope

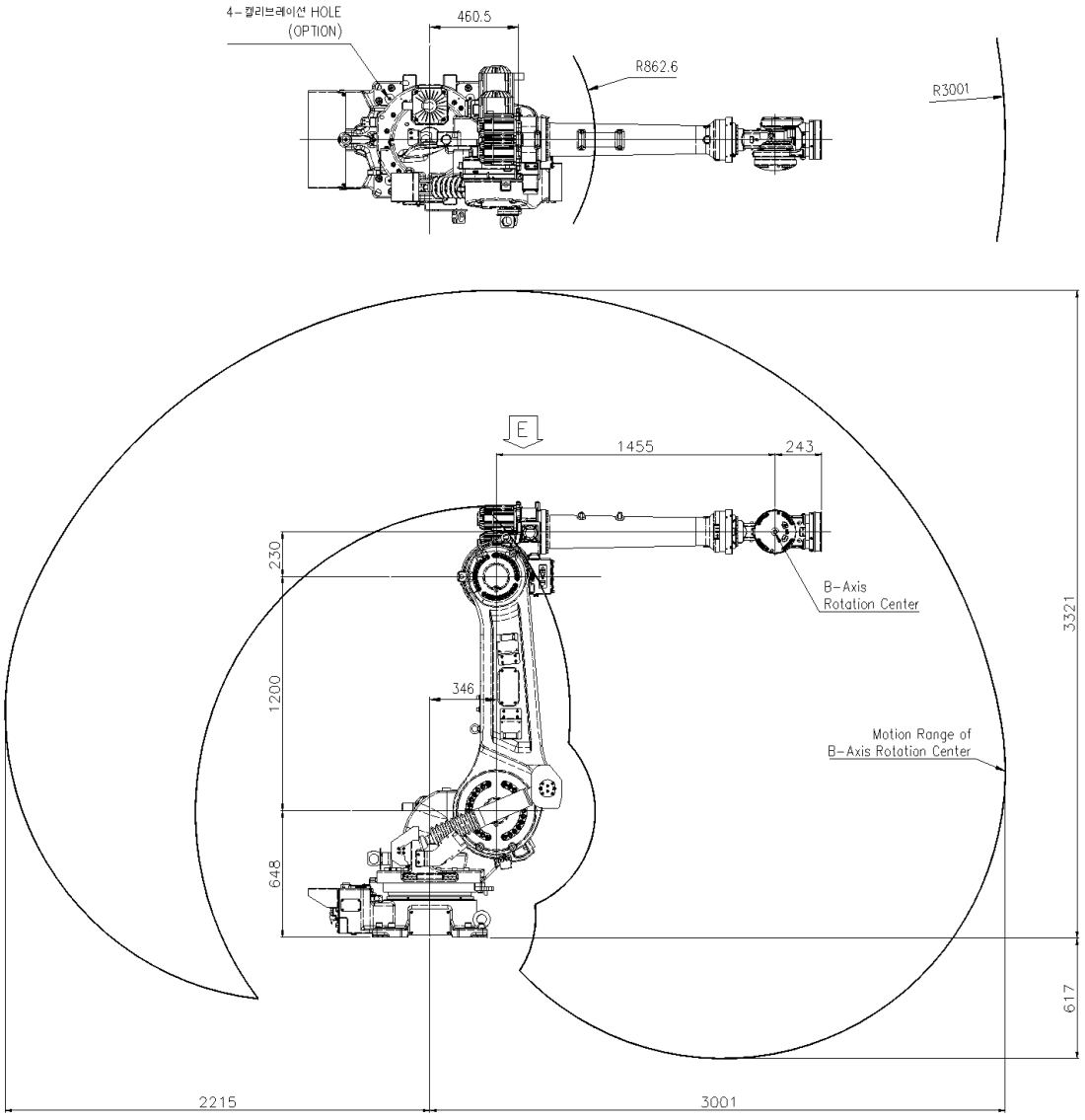


Figure 2.3 Robot Dimension and Working Envelope (HC165L)

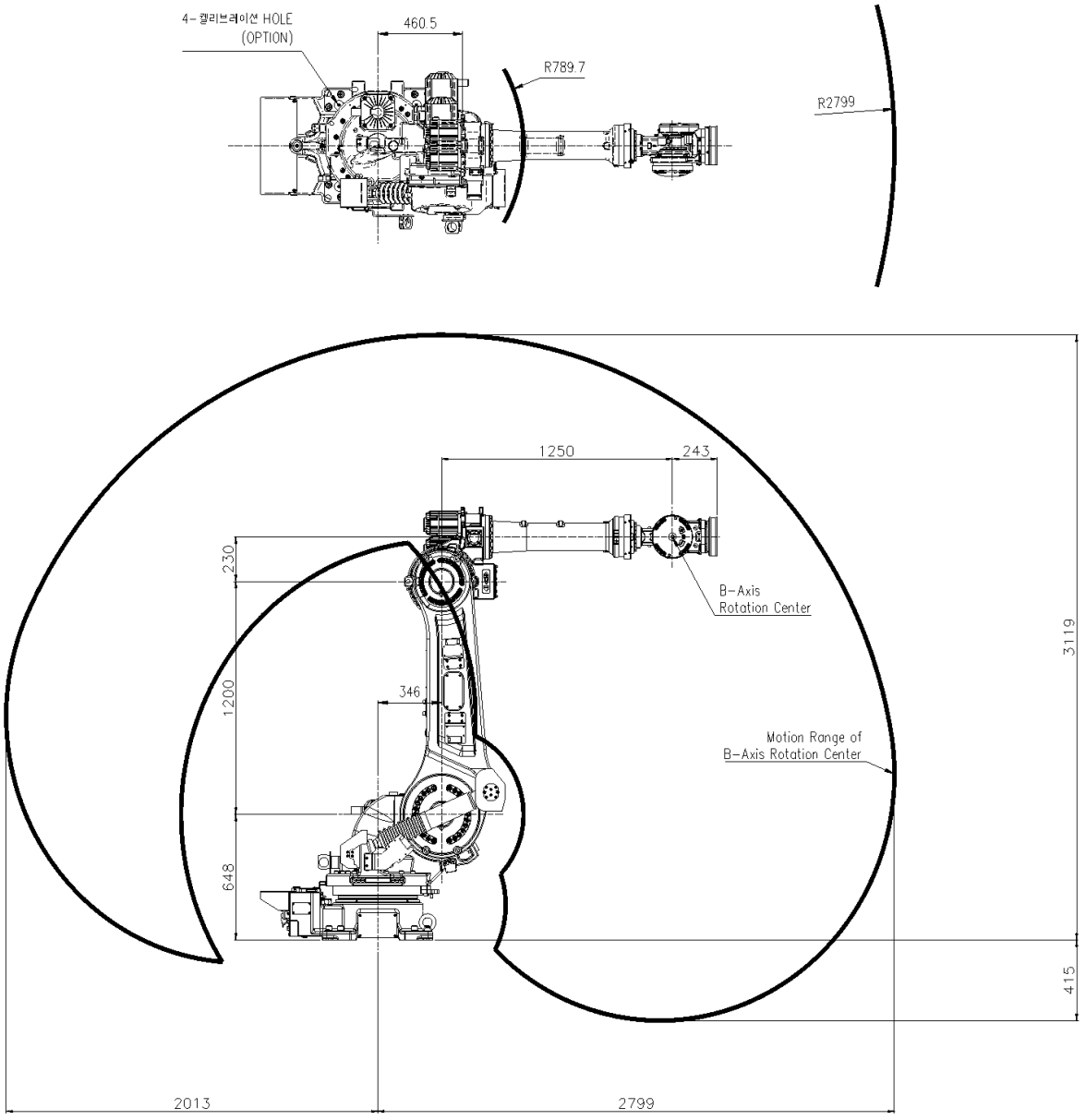


Figure 2.4 Robot Dimension and Working Envelope (HC200)

2.5. Axis Identification

Table 2-2 Axis Motion

Axis Name	Operation	Teach Pendant Button	
S	Arm Swivel	X+(S+)	X-(S-)
H	Arm Forward and Backward	Y+(H+)	Y-(H-)
V	Arm Upward and Downward	Z+(V+)	Z-(V-)
R2	Wrist Rotation 2	RX+(R2+)	RX-(R2-)
B	Wrist Bend	RY+(B+)	RY-(B-)
R1	Wrist Rotation 1	RZ+(R1+)	RZ-(R1-)

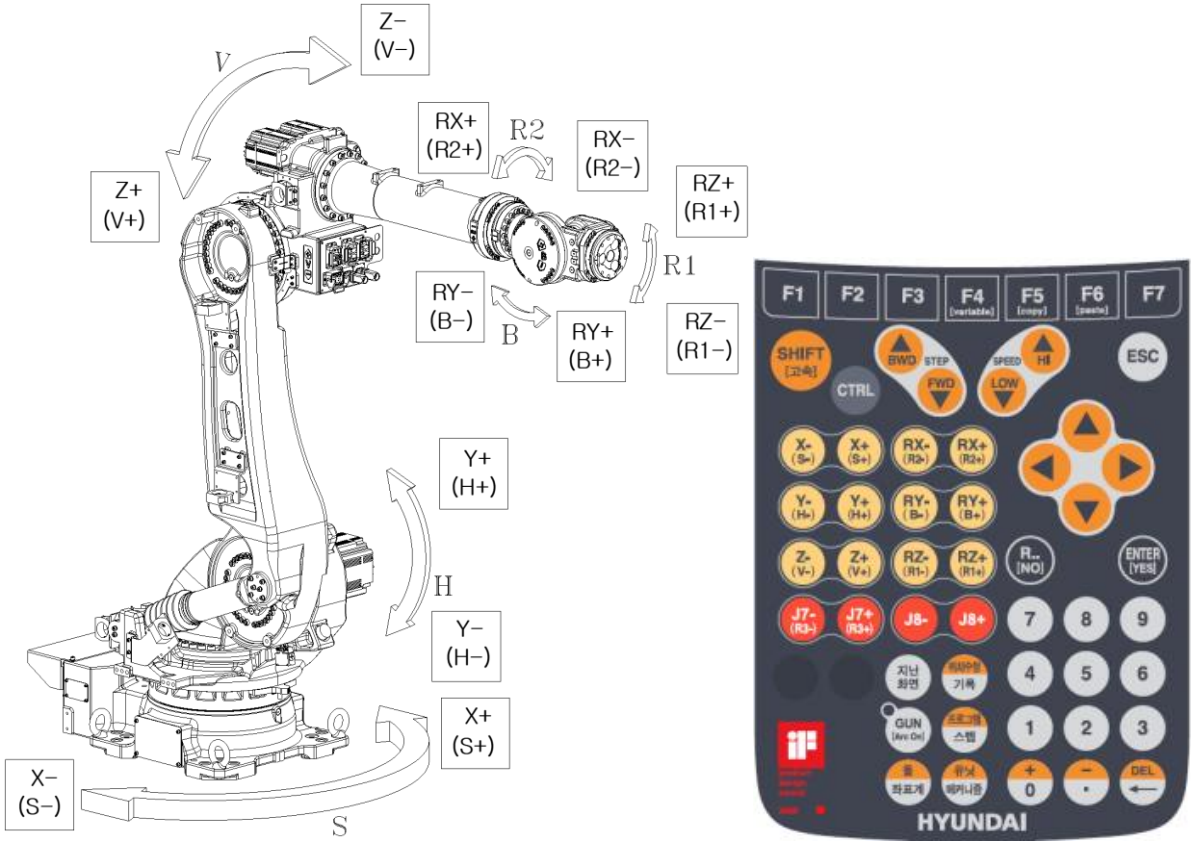


Figure 2.5 Robot Dimension and Axis

2.6. Details of Wrist Axis Attachment Surface

When attaching the operating tool to the mechanical interface of robot's wrist flange, fasten it with a bolt at P.C.D. 160

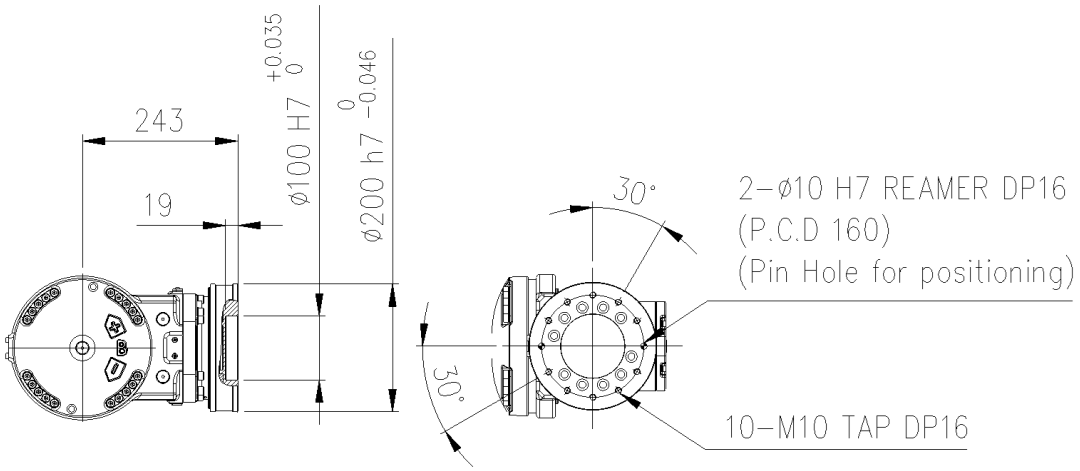


Figure 2.6 Details of Wrist Axis Attachment Surface

2.7. Details of ARM Frame Attachment Surface

The upper parts of the arm frame and arm pipe of the robots are attached using a tap designed to attach peripheral devices. Within the area marked with ▦, peripheral devices (valves, etc.) shall be attached.

[Attention]

Peripheral devices shall be attached either on the upper part of the arm frame or the upper part of the arm pipe. When attaching, be sure to the center position of gravity should be located within the range marked as ▦.

- Max weight on the ARM PIPE : 20kg

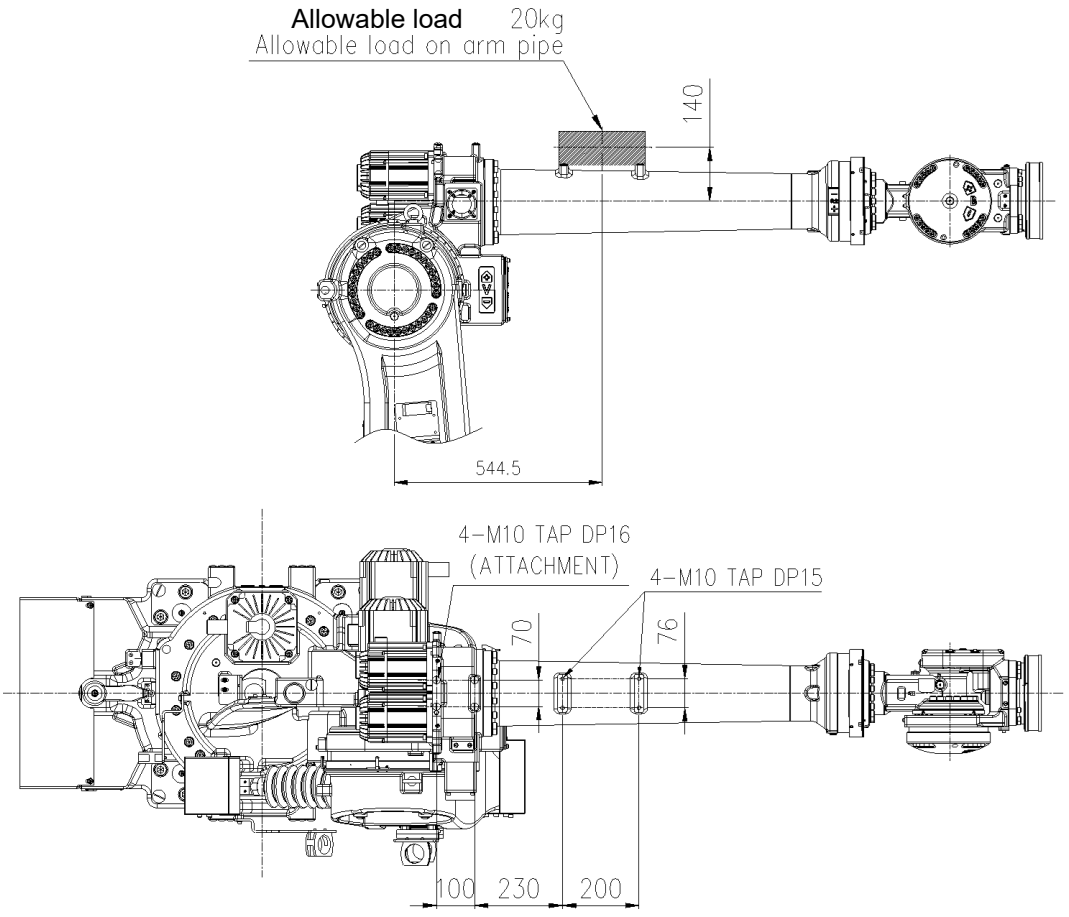


Figure 2.7 Details of Upper ARM FRAME Attachment Surface (HC165L)

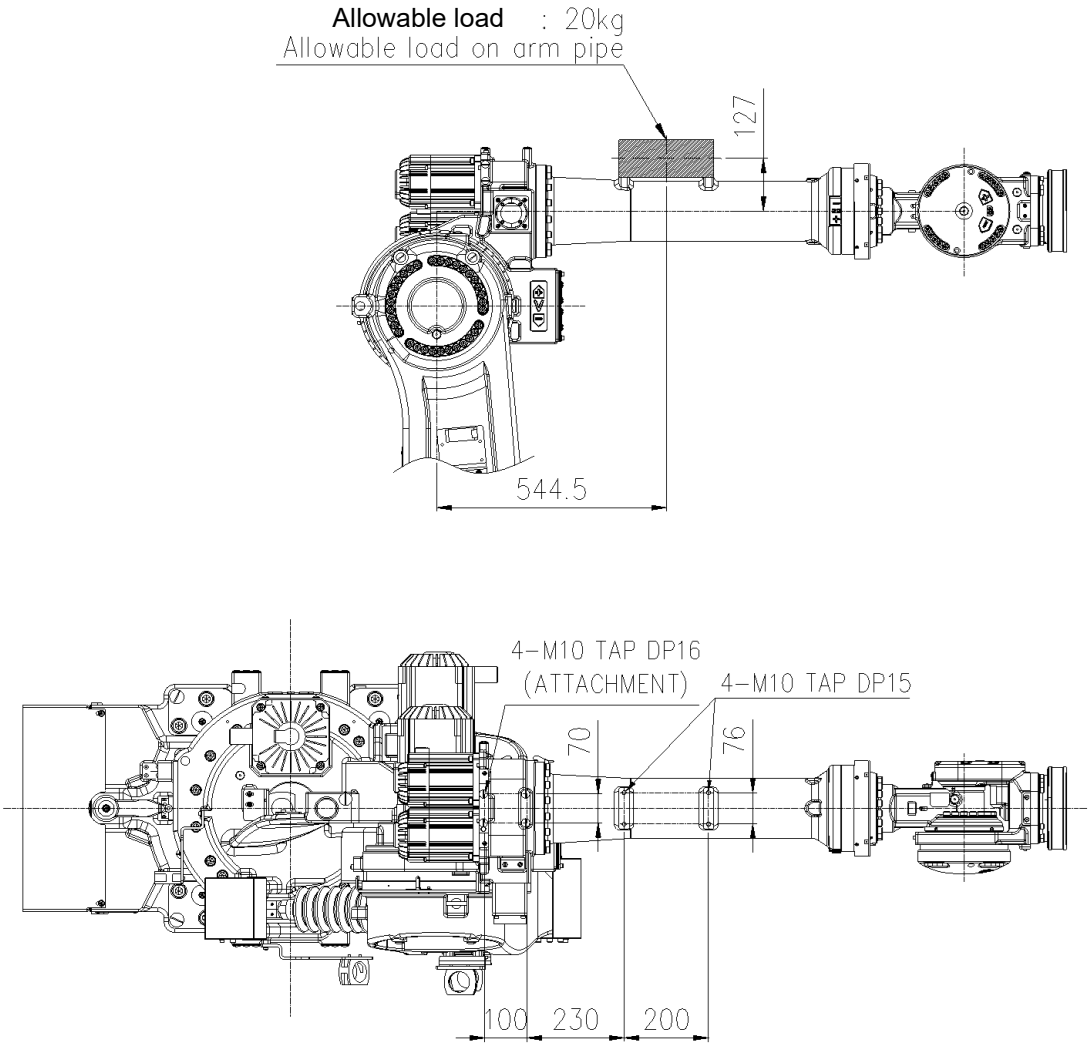
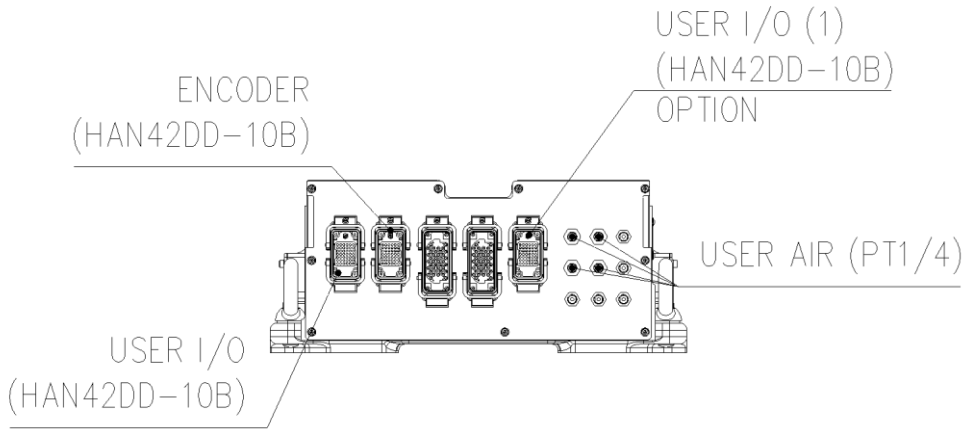


Figure 2.8 Details of Upper ARM FRAME Attachment Surface (HC200)

2.8. Application Wiring and Inspection Wiring Diagram

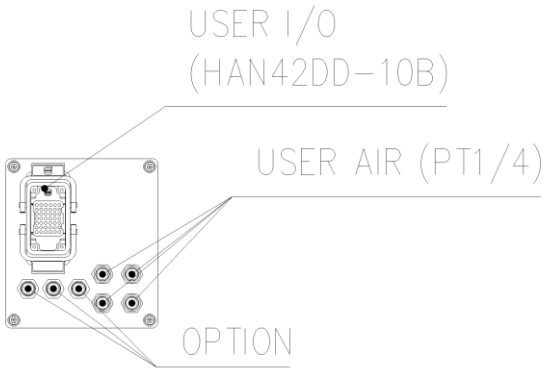
There are air unit and connector to connect the additional equipment to the robot manipulator. Application connectors are indicated as follows.

[Note] Max air pressure of air connection: 5bar (5.1 kgf/cm^2, 72.5 psi)



. BASE BODY PART

Figure 2.9 Application Wiring and Inspection Wiring Diagram



ARM FRAME PART

Figure 2.10 Application Wiring and Inspection Wiring Diagram

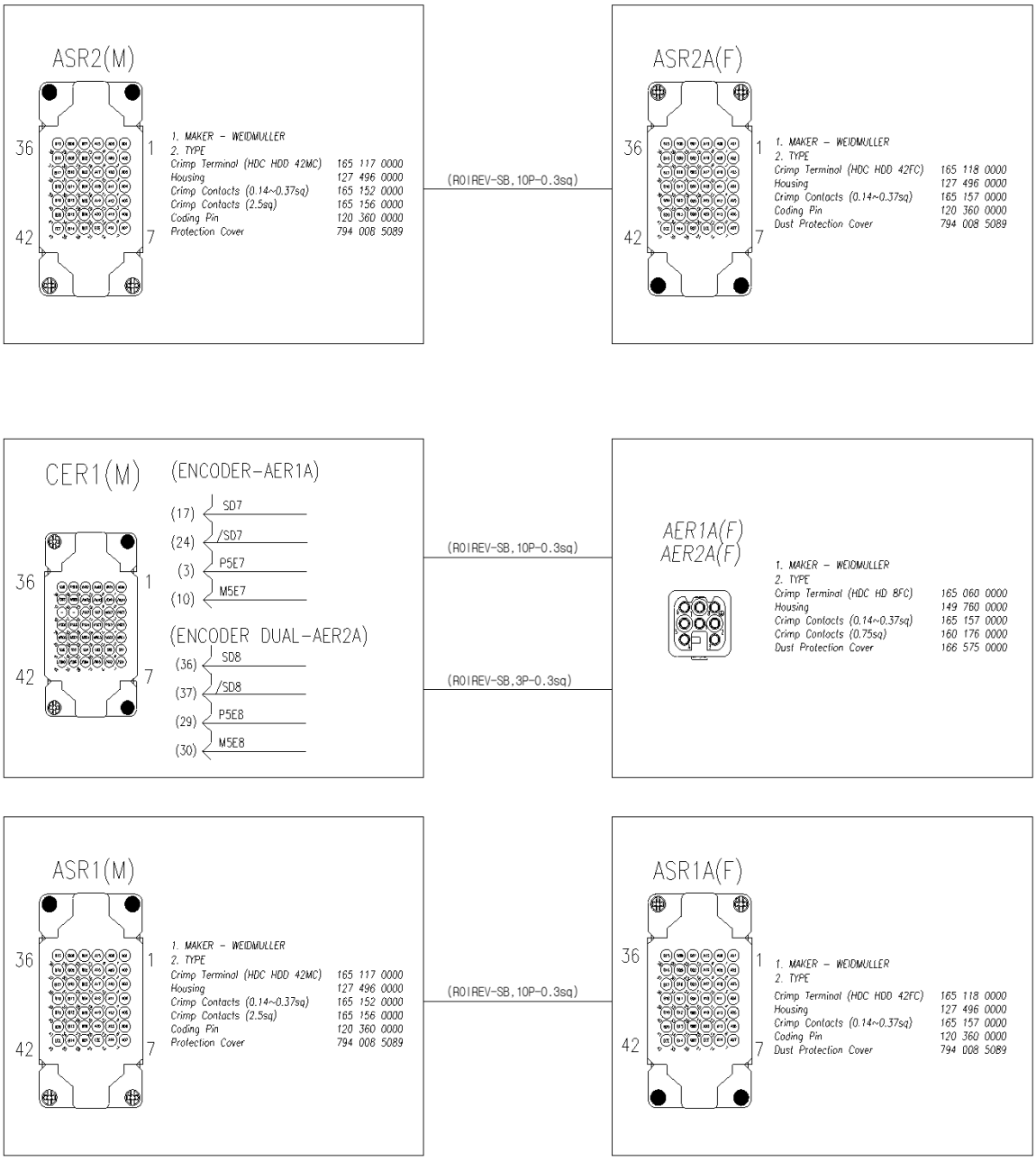


Figure 2.11 Details of Application Connector

2.9. Restricting the Working Envelope

When installing the robot, take into account that the working envelope can be adjusted freely within the entire working envelope

Limiting the motion range is useful when:

- During robot operation
- When the robot is likely to collide with another device
- When the length of the application cables or hose pipes are limited

There are three methods to use to limit the motion range of the robot as follows:

- Software limit (applied to the entire axis)
- Limit switch (1-3 axis: optional application)
- Mechanical stopper (1-3 axes)

[Warning]
The mechanical stopper is a physical device. The robot should not exceed the area occupied by the mechanical stopper. The mechanical stopper of a 1-3 and 5 axis is fixed. The mechanical stopper with a 4, 6 axis is applied only within the software limits

Once the mechanical stopper is collided with, its strength cannot be guaranteed. Therefore, please ensure it is replaced after impact

2.9.1. Axis 1(Axis S)

By adding one more mechanical stopper, the working envelope of the 1st axis can be limited. (by 30˚)
If the 1st STOPPER BLOCK and STOPPER are deformed due to a great impact, they must be replaced

3
Instructions

3.1. Robot Component Name

The following picture shows the names of individual parts

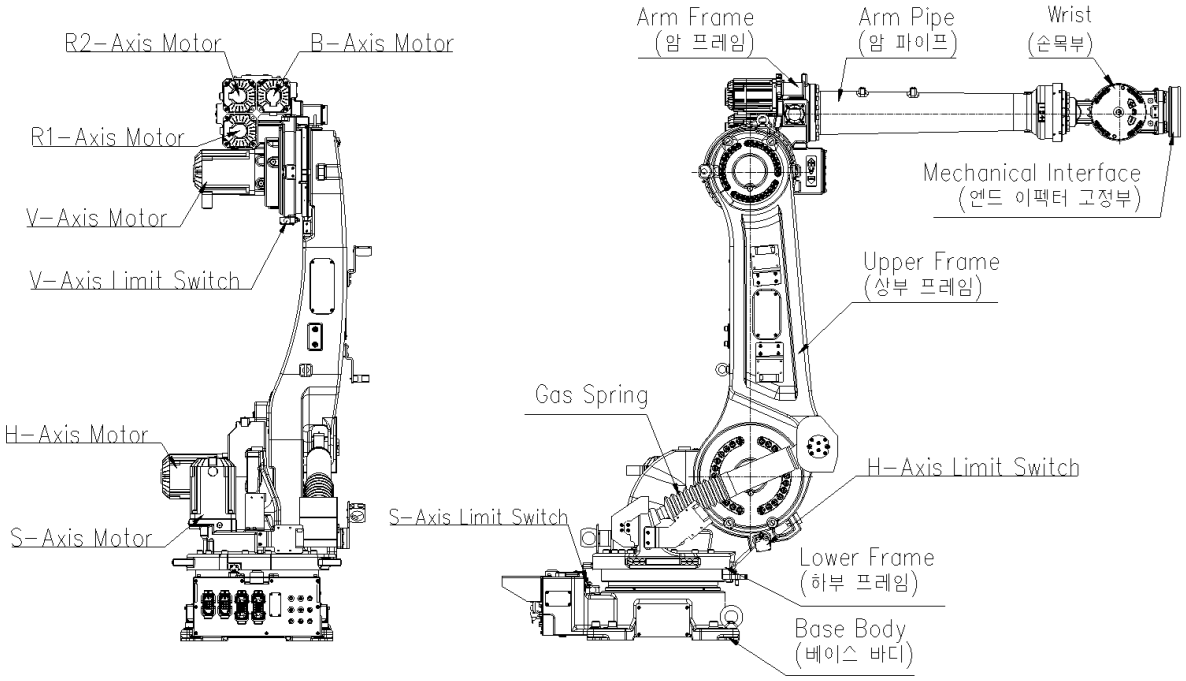


Figure 3.1 Name of Robot Components

[Note] Basic 3-axis limit switch is an option

3.2. Location of Safety Nameplate

To prevent any negligent accident, the main body of a robot has the safety nameplate as shown below. Do not remove or replace it unnecessarily.

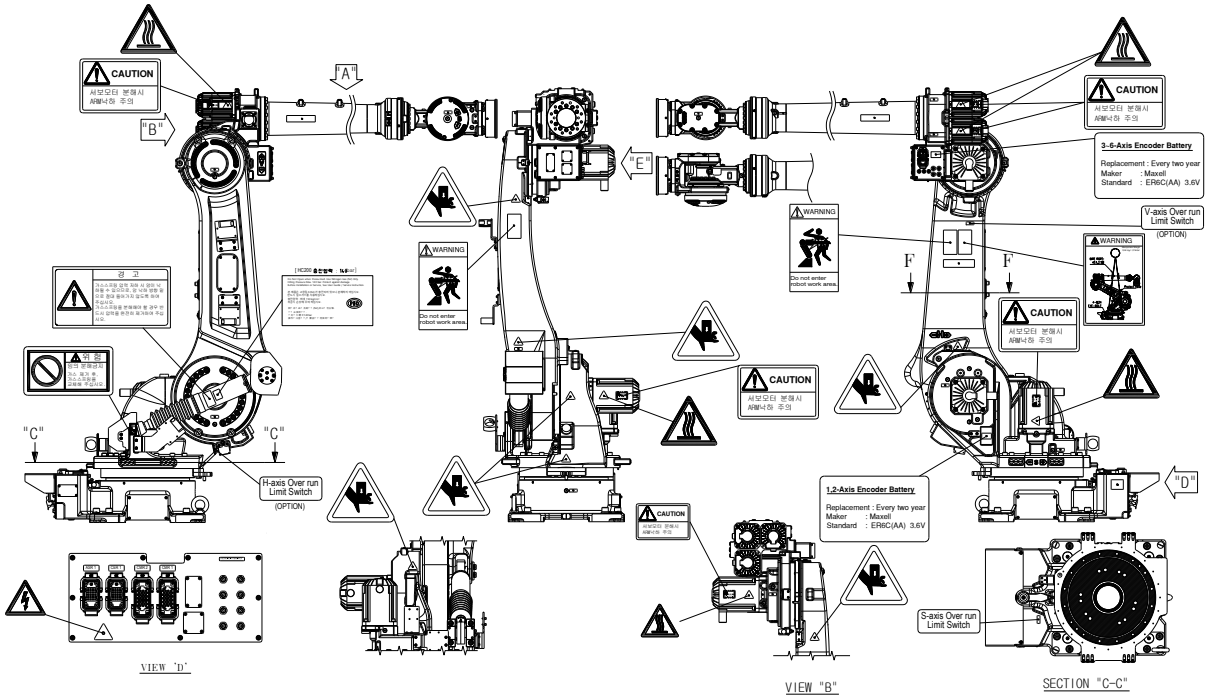


Figure 3.2 Location of Safety Nameplate

3.3. How to Transport

The robot can be transported using a crane or a forklift. When moving the root, it needs to be shifted into a proper position, as shown below, for transportation. Then, the robot can be moved using eyebolts and specified transportation equipment.

- When lowering or moving the robot, please be very careful by moving it slowly.
- When lowering the robot onto the floor, take precaution not to cause the bottom surface to harshly impact the floor.
- Never use any other no specified transportation equipment and methods.
- When transporting the robot, be very careful not to allow the motors, connectors, cables, etc. of the robot to be damaged by the crane wire or forklift.
- When transporting the robot, make it keep its horizontal level.
- When transporting the robot using a forklift, check the bolts fixing the transport equipment and tighten any loose bolts.
- When disassembling or assembling the transport equipment (forklift brackets), the manipulator will slide. Secure the robot with bolts using the robot fixing bolt holes to prevent the robot from falling over.

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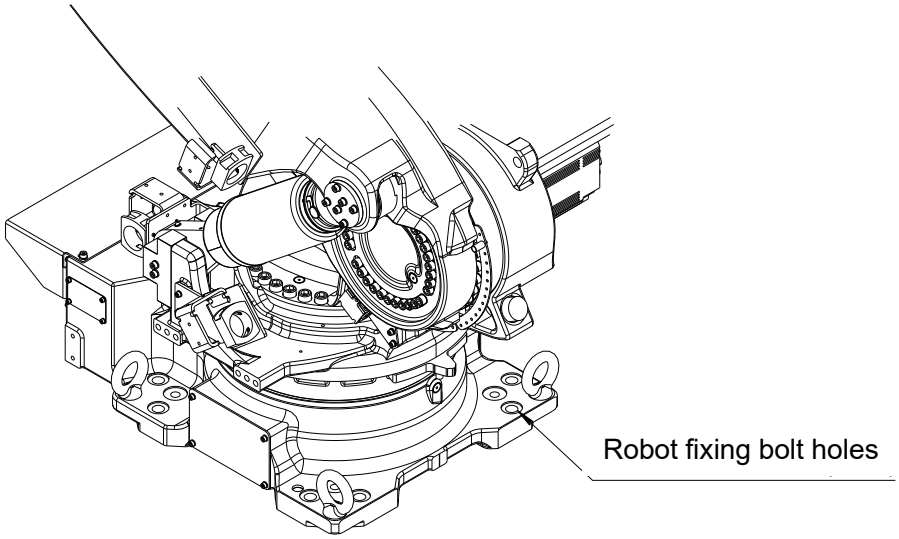
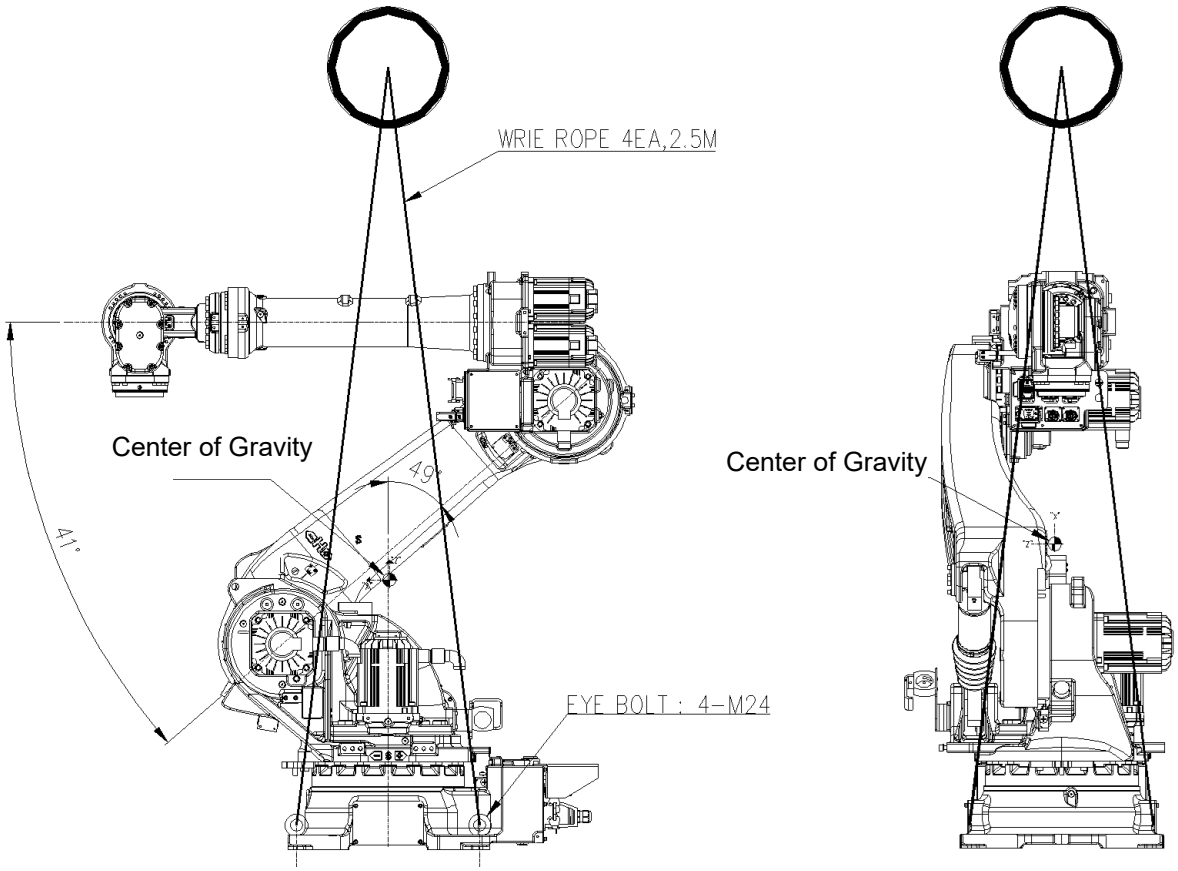


3.3.1. Using Crane



S- Axis	0
H- Axis	150
V- Axis	-60
R2- Axis	0
B- Axis	-90
R1- Axis	0

Figure 3.3 How to Transport: Using crane

The following lifting instructions are valid for a "naked" robot. If additional equipment is put on the robot, the center of gravity may change and make lifting dangerous.

- Never walk under the robot
- Pose the robot as shown in the Figure
- Install the 4-M24 eyebolt to the base body
- Connect 4 wire ropes to 4 eye bolts
- Min. crane capacity: 2 tons. Min. rope capacity: 1 ton/each
- Use 4 pieces of protective hose (four parts/ 50cm) to prevent damage.
- Keep the safety regulations during Lifting process
- Fix the ropes while taking precaution not to cause damage to the motors, connectors, and cables of the robot
- Weight of manipulator

Model	HC165L	HC200
Weight	1250kg	1220kg

3.3.2. Forklift use

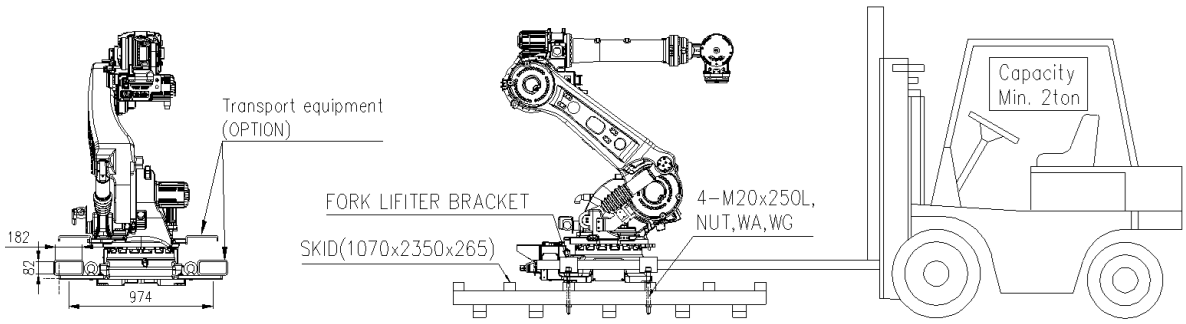
A forklift can be used to carry the main body of the robot.

For safety reasons, please pay attention to the following procedures:

- With reference to the pictures provided, use the standard position of each model.
- Check whether the fixing bolts of the transport equipment (forklift brackets) are loose, and tighten them to ensure that they are not loose.
- The transport equipment should be sufficiently durable in terms of strength.
- Make sure that there is no collision between the forks of the forklift and the transporting equipment.
- Before transporting the robot with a forklift, check that the robot is in leveled posture.
- Transport it at low speed.
- Observe the safety regulations.

Cautions

- Do not lean against the robot while carrying it.
- Make sure the robot does not collide with the floor while loading and unloading.
- Pay attention to the relevant safety rules while using the forklift truck.
- When transporting the robot with a forklift by using a skid plate, check whether bolts are loose, and tighten them to make sure that they are not loose.
- Disassemble the transport equipment before operating the robot to prevent a collision between the transport equipment and the robot.



S- Axis	0
H- Axis	150
V- Axis	-60
R2- Axis	0
B- Axis	-90
R1- Axis	0

Figure 3.4 How to Transport : Using forklift

3.4. Storage of the robot

To store the robot for non-use, position it as shown in [Figure 3.5].

[Caution]
If not placed as instructed, the robot may fall. For long-term storage, take extra care to ensure that it does not fall.

3.5. How to Install

NOTE:
Before starting to unpack and install the robot, read the safety regulations and other instructions very carefully.
When there is a need to use the robot in an environment not specified in the usage conditions, please contact the service center.

Warning:
The installation shall be made by qualified installation personnel and should conform to all national and local codes.
When unpacking the robot, check if it has been damaged during transporting or unpacking. In addition, strictly keep the following installation instructions because installation method and foundation are very important to maintain a good robot performance.

3.5.1. Operating Conditions

(1) Ambient temperature should range from 0℃ to 45℃.
(2) Ambient humidity should range from 20% to 85% RH, without dew condensation.
(3) Less dust, oil, or moisture.
(4) No flammable, corrosive liquid or GAS.
(5) No impact and shacking.
(6) No electrical noise generator near the robot.
(7) If the robot is not immediately installed, keep it in a dry area at an ambient temperature between -15℃～ and 40℃.

3.5.2. Installation the Robot Manipulator

The base floor to install the robot should be constructed with concrete with a thickness of 300mm or more so that the hardness minimizes dynamic effect to the robot. Repair bumps and cracks on the concrete surface of the floor during installation, and fix the mounting place with M20 Chemical Anchor. And if the thickness of the concrete floor is less than 300mm, it requires an independent base construction that must be reviewed beforehand.
Locate the robot unit on the mounting plate and tightly assemble 8ea M20 bolts.

- Bolt: M20*70 (Hardness level: 12.9)
- Flat washer: T = 4mm or above, internal diameter (ID) = 24mm, hardness of HrC 35 or above
- Assembly torque: 5700 kgfcm

3.5.3. Accuracy of Installation Surface

The flatness of the robot installation surface should be 0.5 mm or less.
If the flatness exceeds the value, the robot may not exert its performance because of deformation and damage to the base body.

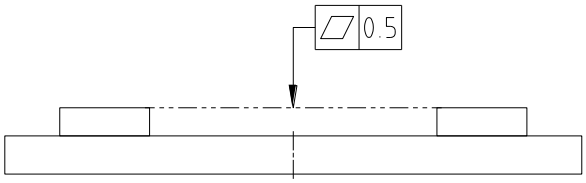


Figure 3.5 Accuracy of Installation surface

3.5.4. Dimension of Installation Surface

Fix the swivel base for robot's installation.
Refer to the following picture for the dimensions.

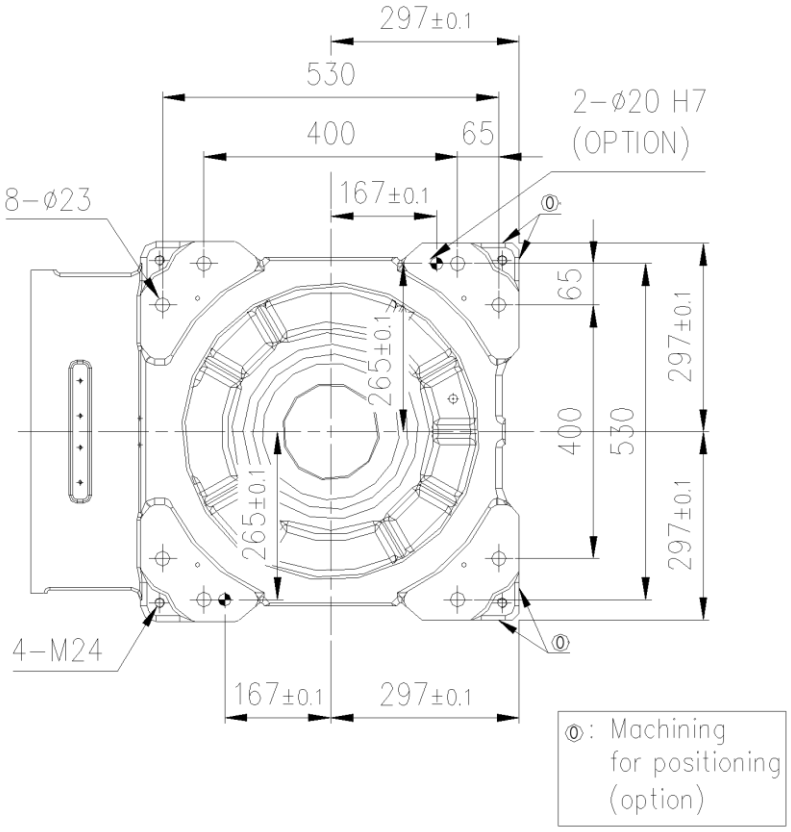


Figure 3.6 Dimension of Robot Installation

3.5.5. Robot Cable Connection

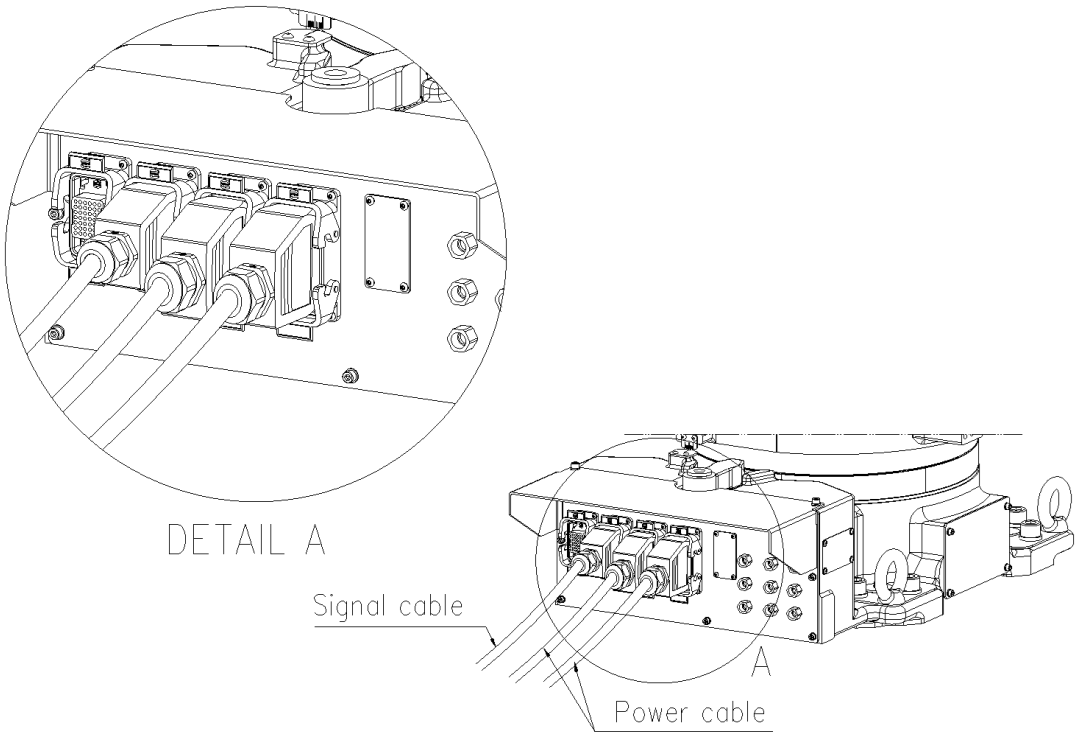


Figure 3.7 Robot Cable Connection

The robot will be connected to the controller with power cables and a signal cable. Connect the cables to the connectors on the rear of the robot base. Connect the ground wire as well.
For the connection of pneumatic pressure cables and option cables, refer to “2.8 Application Wiring and Inspection Wiring Diagram”.

Make sure to turn OFF the power of the controller before connecting the cables.

3.5.6. Emergency stop time & distance

The following items are the response time and distance for an emergency stop during the max speed operation of each axis (S, H, and V) with the standard load.

- HC165L
  Max Time: 0.51 seconds
  Max Moving Distance: 42.06 inch / 103.89 cm

- HC200
  Max Time: 0.5 seconds
  Max Moving Distance: 41.73 Inch / 106.0 cm

3.6. Allowable Load of Wrist Axis

3.6.1. Permitted load torque estimation

The load, which will be applied to the mechanical interface of robot's wrist axis, is restricted by allowable weight, allowable load torque and allowable moment of inertia. The direction of coordinate system used to calculate the load torque and inertia moment is the same with the direction of robot base coordinate system. Axis R2 is reviewed in the same manner with the axis B

- Step 1
  Calculate the location of the weight center from the B axis rotation center (L_X, L_Y, L_Z)
  L_X: Location of weight center in X axis
  L_Y: Location of weight center in Y axis
  L_Z: Location of weight center in Z axis

- Step 2
  Distance calculation from the axis B and R1 to the center of gravity
  $$L_B = \sqrt{L_X{}^2 + L_Z{}^2}, \quad L_{R1} = \sqrt{L_Y{}^2 + L_Z{}^2}$$

  L_B : Length from B axis rotation center to weight center
  L_{R1} : Length from R1 axis rotation center to weight center

- Step 3
  Calculate the load torque from the calculated distance.
  $$T_B = MgL_B \qquad T_{R1} = MgL_{R1}$$

  T_B: Load torque in the rotational center of axis B
  T_{R1}: Load torque in the rotational center of axis R1
  M: Mass of load
  g: Acceleration of gravity

- Step 4
  Check if the load torque calculated in the step 3 is the same with or smaller than the limit value, on the basis of allowed load torque table.

- Note: If the load mass is similar to the mass on the torque curve below, the torque can be alternatively validated by checking if the distance calculated in the step 2 is distributed in the torque curve, instead of the step 3 and 4. If it is in the torque curve, the calculated load torque is smaller than the allowed load torque but if it is out of the torque curve, the calculated load torque is bigger than the allowed load torque

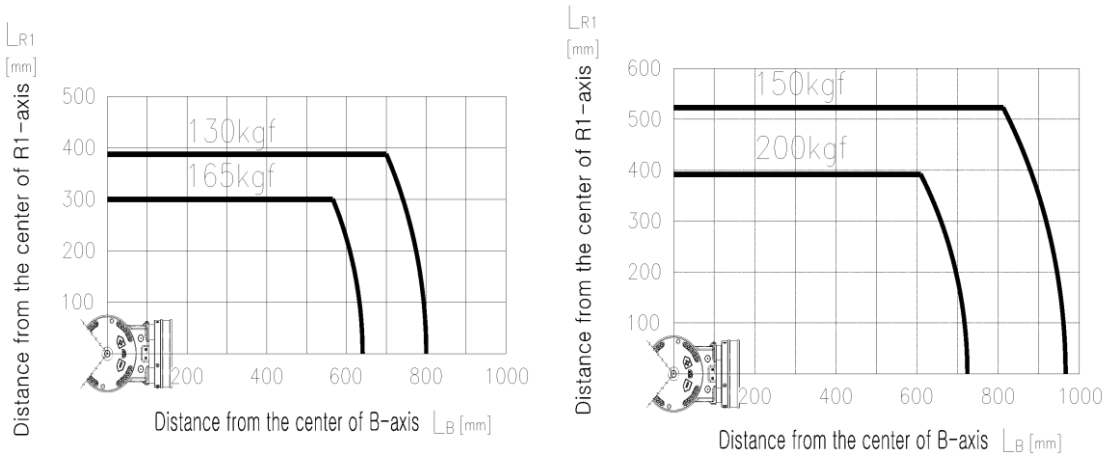


Figure 3.8 Wrist Axis Torque Mapping (Left : HC165L, Right : HC200)

Allowable Load Torque

Table 3-1 Allowable Load Torque

Maximum Payload	Allowable Load Torque		
	R2 Axis Rotation	B Axis Rotation	R1 Axis Rotation
HC165L	Less than 1,030N·m(105kgf·m)	Less than 1030 N·m(105 kgf·m)	Less than 490 N·m(50 kgf·m)
HC200	Less than 1,422N·m(145kgf·m)	Less than 1422N·m(145 kgf·m)	Less than 770N·m(79 kgf·m)

3.6.2. Permitted inertia moment estimation

Loads must be kept below maximum conditions shown in [Table 3-2].

- Step 1
  Calculate the inertia moment value of the load at each wrist axis center (J_{a4}, J_{a5}, J_{a6})
  J_{a4}- Inertia moment from R2 axis rotation center
  J_{a5}- Inertia moment from B axis rotation center
  J_{a6}- Inertia moment from R1 axis rotation center

- Step 2
  Check whether the inertia moment value is within the limit based on the allowed inertia moment table

Allowable Moment of Inertia

Table 3-2 Allowable Moment of Inertia

Maximum Payload	Allowable Moment of Inertia		
	R2 Axis Rotation	B Axis Rotation	R1 Axis Rotation
HC165L	78.5 kg · m² (8kgf · m · s²)		40.2 kg · m² (4.1kgf · m · s²)
HC200	152 kg · m² (15.5kgf · m · s²)		86 kg · m² (8.8kgf · m · s²)

3.6.3. Example of permitted torque and inertia moment calculation (HS180 Case)

(1) Case #1 Simple 2-D model

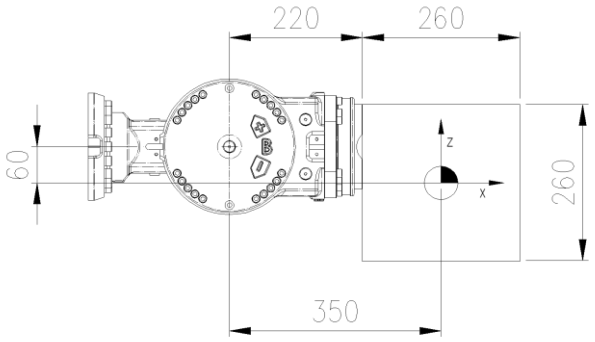


Figure 3.9 2-D load model

M – Load weight
J_{xx} – Inertia moment in X direction from weight center of load
J_{yy} – Inertia moment in Y direction from weight center of load
J_{zz} – Inertia moment in Z direction from weight center of load
J_{a4} – Inertia moment from R2 axis rotation center
J_{a5} – Inertia moment from B axis rotation center
J_{a6} – Inertia moment from R1 axis rotation center

☞ Load condition: Stainless steel with length and width of 260mm and thickness of 260mm (Mass 138.15kg)

① Weight limitation
Load weigh t: $138.15 \leq 180$ kg

② Permitted torque limit
Location of B axis weight center L_X = 350mm, L_Y = 0mm, L_Z = -60mm
The distance from the axis B and R1 to the center of gravity can be calculated as follows
Length in B axis $L_B = \sqrt{0.35^2 + 0.06^2} = 0.355$ m
Length in R1 axis $L_{R1} = 0.06$ m
Load torque of axis B $T_B = MgL_B = 49.04$ kgfm ≤ 110 kgfm
Load torque of axis R1 $T_{R1} = MgL_{R1} = 8.29$ kgfm ≤ 58 kgfm

③ Permitted inertia moment limit
Inertia moment of load from the weight center J_{xx}= 1.56kgm^2, J_{yy}= 1.56 kgm^2, J_{zz}= 1.56 kgm^2
B axis inertia moment (Ja5)
$J_{a5} = ML_B^2 + J_{yy} = 138.15 \times 0.355^2 + 1.56 = 18.97 \leq 106$ kgm^2
R1 axis inertia moment (Ja6)
$J_{a6} = ML_{R1}^2 + J_{xx} = 138.15 \times 0.06^2 + 1.56 = 2.06 \leq 56$ kgm^2

④ Conclusion
It is safe because the weight, torque and inertia moment all satisfy the limited condition.

(2) Case #2 Complicated 3-D model

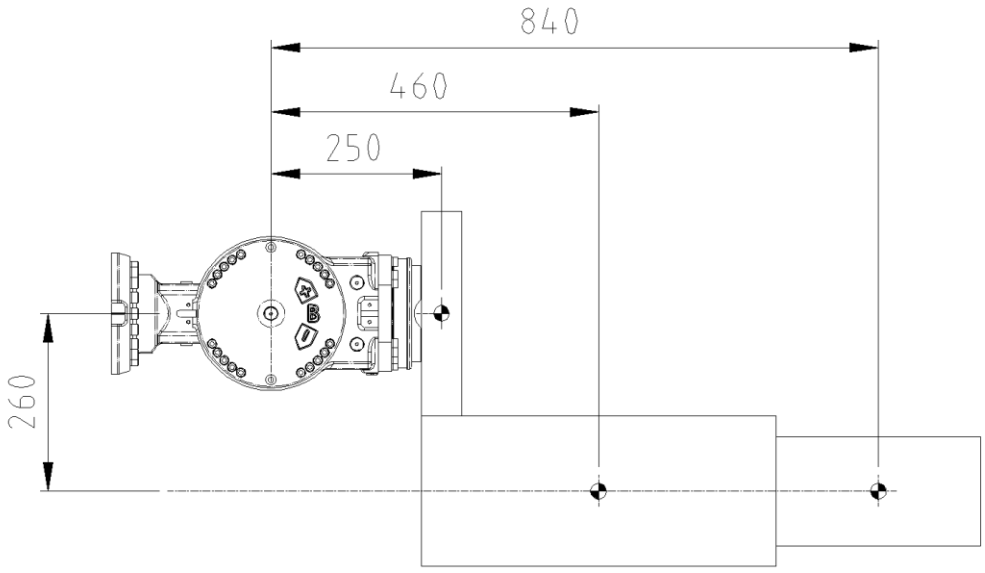


Figure 3.10 3-D load model 2-D shape

Aluminum block shape combination
(σ=0.0027 g/mm^3: 176.3 kg)
m1 (60×300×300) 14.6kg
m2 (480×440×220) 125.4kg
m3 (280×300×160) 36.3kg

mi – Weight of 'i' block load
L_{Xi} – Weight center location in X axis direction of 'i' block
L_{Yi} – Weight center location in Y axis direction of 'i' block
L_{Zi} – Weight center location in Z axis direction of 'i' block

① Weight limitation
Load weight : $176.3 \leq 180$ kg

② Permitted torque limit

You can calculate the weight center location for the total load from the B axis rotation center as follows.

$$L_x = \frac{\sum_i m_i L_{xi}}{\sum_i m_i} = \frac{14.6 \times 250 + 125.4 \times 460 + 36.3 \times 840}{176.3} = 520.85 \text{ mm}$$

$L_y = 0$ mm (Symmetric to Y axis)

$$L_z = \frac{\sum_i m_i L_{zi}}{\sum_i m_i} = \frac{14.6 \times 0 + 125.4 \times 260 + 36.3 \times 260}{176.3} = 238.47 \text{ mm}$$

The weight center location for the total load from the B axis rotation center L_x = 520.85mm, L_y = 0mm, L_z = -238.47mm

Distance from the axis B to center of gravity $L_B = \sqrt{0.521^2 + 0.238^2} = 0.573$ m
Distance from the axis R1 to center of gravity $L_{R1} = \sqrt{0.238^2 + 0.0^2} = 0.238$ m

Load torque of axis B $T_B = MgL_B = 101.02 \text{ kgfm} \leq 110 \text{ kgfm}$
Load torque of axis R1 $T_{R1} = MgL_{R1} = 41.96 \text{ kgfm} \leq 58 \text{ kgfm}$

x1 y1 z1 – x, y and z direction length of block m1
x2 y2 z2 – x, y and z direction length of block m2
x3 y3 z3 – x, y and z direction length of block m3

L_{X1}, L_{Y1}, L_{Z1} – Weight center location of block m1 from B axis rotation center
L_{X2}, L_{Y2}, L_{Z2} – Weight center location of block m2 from B axis rotation center
L_{X3}, L_{Y3}, L_{Z3} – Weight center location of block m3 from B axis rotation center

J_{xx1}, J_{yy1}, J_{zz1} – Inertia moment by x, y and z axis from the weight center of block m1
J_{xx2}, J_{yy2}, J_{zz2} – Inertia moment by x, y and z axis from the weight center of block m2
J_{xx3}, J_{yy3}, J_{zz3} – Inertia moment by x, y and z axis from the weight center of block m3

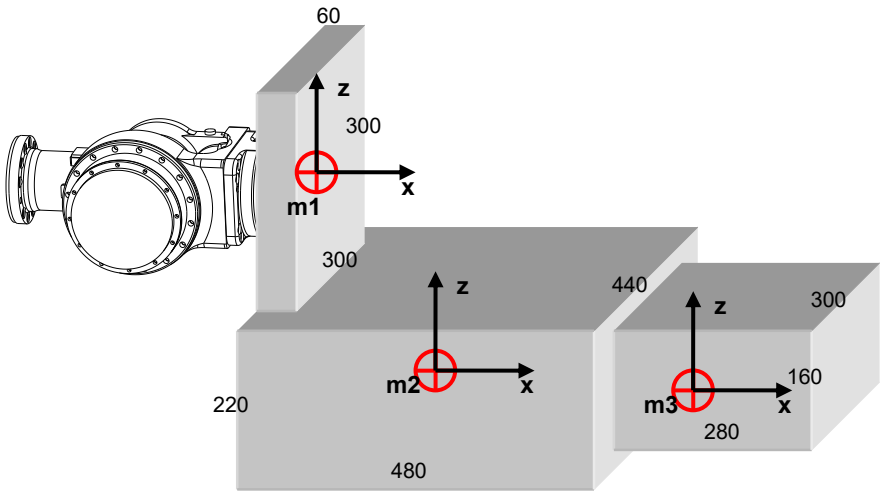


Figure 3.11 3-D load model 3-D shape

③ Permitted inertia moment limit

Table 3-3 Inertia moment from weight center by block

Block weight (kg)	Weight center (L_x, L_Y, L_Z)	J_{xx}	J_{yy}	J_{zz}
m_1 (14.6)	(0.25, 0, 0)	0.219 kgm^2	0.114 kgm^2	0.114 kgm^2
m_2 (125.4)	(0.46, 0, -0.26)	2.530 kgm^2	2.915 kgm^2	4.433 kgm^2
m_3 (36.3)	(0.85, 0, -0.26)	0.350 kgm^2	0.314 kgm^2	0.509 kgm^2

B axis inertia moment (J_{a5})

$$J_{a5} = \sum_i \left[m_i(L_{xi}^2 + L_{zi}^2) + J_{yyi}\right]$$
$$= [14.6 \times (0.25^2) + 0.114] + [125.4 \times (0.46^2 + 0.26^2) + 2.915]$$
$$+ [36.3 \times (0.85^2 + 0.26^2) + 0.314] = 67.95 \leq 106\ \text{kg}m^2$$

R1 axis inertia moment (J_{a6})

$$J_{a6} = \sum_i \left[m_i(L_{yi}^2 + L_{zi}^2) + J_{xxi}\right]$$
$$= [14.6 \times (0^2) + 0.219] + [125.4 \times (0.26^2) + 2.530]$$
$$+ [36.3 \times (0.26^2) + 0.350] = 14.03 \leq 56\ \text{kg}m^2$$

④ Conclusion
It is safe because the weight, torque and inertia moment all satisfy the limited condition.

4
Inspection

This chapter provides the instructions for regular inspection and overhaul necessary for the prolonged lifetime of robot performance

4.1. Inspection Schedule

Inspection is positively necessary to continue and maintain the high performance of robot for long-term operation
There are daily inspection and regular inspection. [Table 4-1] shows basic periods for regular inspections, so inspectors should make an inspection according to the indicated periods
And overhaul every 35,000 operating hours

The inspection periods have been reviewed for SPOT Welding. In case of high precision work such as handling, it is recommended to inspect at the half intervals of that period as shown in [Table 4-1]
If you have difficulty in understanding the inspection and adjustment methods, please contact the Hyundai Robotics A/S Center (Customer Support)

Table 4-1 Inspection Schedule

Daily Inspection	**Daily**	Manipulator, Motor, Reducer, Gas spring, Gas spring bearing
Regular inspection	**3months**	Wirings, bolts, reducers
	6months	Gas springs, bearings of the gas spring
	1 year	Limit switch / Dog, Brake

4.2. Inspection Item and Period

Table 4-2 Inspection Items and Periods

No.	Inspection Intervals				Inspection Items	Inspection method	Standards	Remark
	Daily	3 months	6 months	1 year				
Robot Manipulator and Axes common								
1	○				Cleaning	Examine dirt and dust with naked eyes		
2		○			Inspection wiring	Examine any cable damages Examine cable fixing bracket tightening bolts paint marking with naked eyes Examine any cable cover damages with naked eyes		
3		○			Main bolts	Examine paint marking with naked eyes		
4				○	Limit Switch/ Dog	Check the ON-OFF function of limit switch	Check if the emergency stop lamp is on when the limit switch is ON.	
5	○				Motor	Check the abnormal heating Check the abnormal sound		
6				○	Brake	Check the ON/OFF operation of brake release switch Note) Turn the switch off in a second because the ARM of working axis may be dropped when the brake release switch is on	When the brake release switch is OFF, ARM of End Effect will not be dropped.	
Axis S, H, V								
7	○				Reducer	Leakage check Check the abnormal sound Check the shaking(vibrating)		

No.	Inspection Intervals				Inspection Items	Inspection method	Standards	Remark
	Daily	3 months	6 months	1 year				
8	○		○		Gas spring	Leakage check Filter check Pressure check	125 ~ 140bar.	
9			○		Gas Spring Bearing	Leakage check Abnormal heat generation check Foreign substance/noise check	Maintain the appropriate amount of grease	
Axis R2, B, R1								
10		○			Reducer	Leakage check Check the abnormal sound Check the vibrating		
11		○			End Effect tightening bolts	Examine paint marking with naked eyes		
12		○			Diversion	there is any diversion by rotating each axis to the right and reverse direction	should not feel diversion by touch	

- If the robot is used in adverse conditions (for example, spot welding, grinding, etc.), you need to shorten the inspection cycle to secure the performance of the robot system.
- Inspect all cables that can be seen, and replace damaged ones.
- Check the mechanical bumpers for any deformation or damage. If a bumper is damaged or a dog is bent, replace it immediately.
- Check the tightening torques of the main bolts shown in [Figure 4.1].
- Check for an abnormal sound in auto mode and teaching mode to check the power transmission systems (motors, reducers, etc.) for any abnormality.
- Inspect the gas spring periodically to maintain the proper working pressure, and inject gas when the pressure drops.
- Replace the gas spring after using it for a certain period of time.
- Replace the gas spring every 20,000 hours or when the proper working pressure (125 bar–140 bar) cannot be maintained even after gas is injected.
- If the load estimation has been performed correctly, the gas spring pressure can be checked from the teaching pendant. Therefore, use the gas spring pressure test function by referring to the controller function manual
  There are two pressure test methods: “Command-based gas spring pressure test” and “Gas spring pressure test at stop position.”

It is recommended to use the “Command-based gas spring pressure test” method, which has higher accuracy.

- If the teaching pendant generates an error or warning related to the gas spring pressure drop, you must check the gas spring pressure.

4.3. Inspection of Main External Bolts

The recommended bolt torque is shown in the picture below.
Apply the appropriate torque, where required, using the torque wrench and place the paint marking where the check-up is completed

Table 4-3 Inspection part for main bolts

No.	Inspection parts	No.	Inspection parts
1	H-axis reducer seal bolt	7	ARM PIPE seal bolt
2	H-axis motor seal bolt	8	R2-axis reducer seal bolt
3	V-axis reducer seal bolt	9	Grip assembly seal bolt
4	V-axis motor seal bolt	10	B-axis reducer seal bolt
5	Gas upper plate seal bolt	11	R1-axis reducer seal bolt
6	Wrist-axis motor seal bolt	12	End effect seal bolt

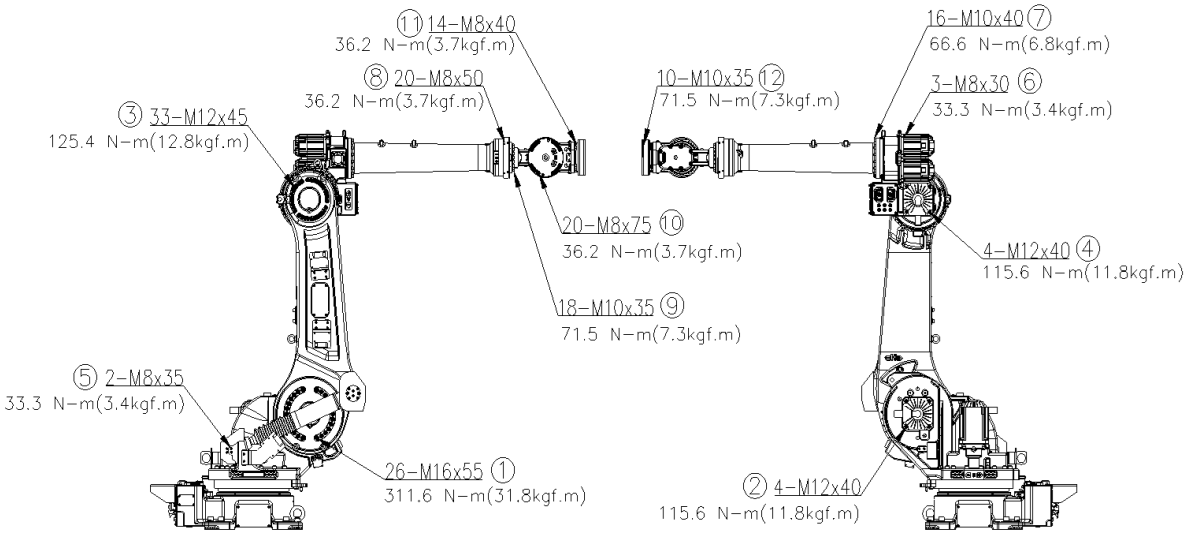


Figure 4.1 Inspection Part for Main Bolts

5
Maintenance

5.1. Grease replacement & Injecting grease after replacing the reducer

Caution

If the grease is not properly injected, the internal pressure in the injection part may suddenly increase, causing the oil seal damage, oil leakage, and abnormal operation. Abnormal sound may be generated when replacing the current grease with new grease of a different specification, so make sure that different types of grease should not be mixed together. Therefore, you must observe the following items when injecting grease.

(1) Make sure to wear safety glasses before injecting grease and inspection.

(2) Before starting to grease, remove the plug from the grease outlet.

(3) When loosening a plug, grease and the plug could be discharged. Block the outlet with a thick cloth to prevent injuries caused by discharged grease or plug, and keep a distance away for safety. (Do not look into the grease outlet.)

(4) Whenever possible, avoid using a compressed-air pump, powered by the factory air supply. If the use of a compressed-air pump is unavoidable, restrict the greasing pressure less than 1.5bar(1.5kgf/cm2,0.15MPA)

(5) Use grease only of the specified type. If not, may damage the reducer or lead to other problems

(6) After greasing, confirm that no grease is leaking from the grease outlet and that the grease bath is not pressurized, After removing the residual pressure of each axis according to the given method, then re-attach the plug in the grease outlet.

(7) To prevent accidents caused by slipping, completely remove any excess grease from the floor or robot

(8) When an ambient temperature is more than 35℃, be sure to shorten the period of replenishment in half

(9) When replacing grease, replace the specified amount and inject new grease as much as the amount of the discharged grease.

(10) If an abnormal sound is generated from the reducer part during operation after replenishment or replacement of grease, at low temperature, at low speed, or after long-term non-operation, you need to operate the robot while checking the state of the abnormal sound for one or two days. Abnormal sound caused by grease will disappear.

(11) If the grease with a different specification is injected into the reducer part that has been greased already, an abnormal sound may occur. Therefore, do not mix these different types of grease. Please replace Vigo grease with Vigo grease and Eureka grease with Eureka grease.

(12) An abnormal sound may occur even if the existing grease is replaced with the new grease of the same designated specification as the existing grease.

(13) Replacing the grease is not for completely removing the existing grease. A significant amount of existing grease will remain.

■ Procedure in discharging excessively fueled grease and residual pressure after grease replacement and injection

(1) Attach a grease receiver or a hose to the grease outlet to prevent contamination from discharged grease.

(2) Operate it within a range without surrounding and interference under the following conditions

Axis	Operation angle (1 axis /2 axis /3 axis)	Operation speed	Operation time
1 axis ~ 3 axis	80° /90° /70° or more	50 %	Least 20 min
4 axis ~ 6 axis	60° /120° /60° or more	100 %	Least 20 min
Arm Frame Gear Box	60° /120° /60° or more	100 %	Least 20 min

(3) Wipe the outlet port with a cloth and attach the plug.

■ **Grease replacement cycle**

Grease replacement cycle

- ✓ **S-axis Reducer, Arm Frame Gear Box: 24,000 hours**
- ✓ **Other Reducers : 12,000 hours**
- ✓ **Gas spring Bearing: 6 months (3 months for severe use)**

If there is still noise in the reducer even after using specified grease, check the state closely for 1-2 days during operation. Generally, the noise will go away.
(The noise will go away if you run the axis at a high speed for 5-10 minutes).

- It can be checked if the abnormal sound will disappear even when the concerned axis is operated at high speed for about 5 to 10 minutes or more.
- When the old grease is discharged as much as possible (about 90% or more) and replaced with new grease, the abnormal grease sound can be minimized. (When the grease is discharged while the axis is rotating at low speed, the grease discharge time can be shortened.)

An abnormal sound usually occur in the following cases:

- During operation after replacement of grease/reducer
- During operation after a long-term non-operation
- During operation at low speed
- During operation at low temperature
- When using unspecified grease
- Mixing grease of different specifications

5.1.1. S-Axis Reducer

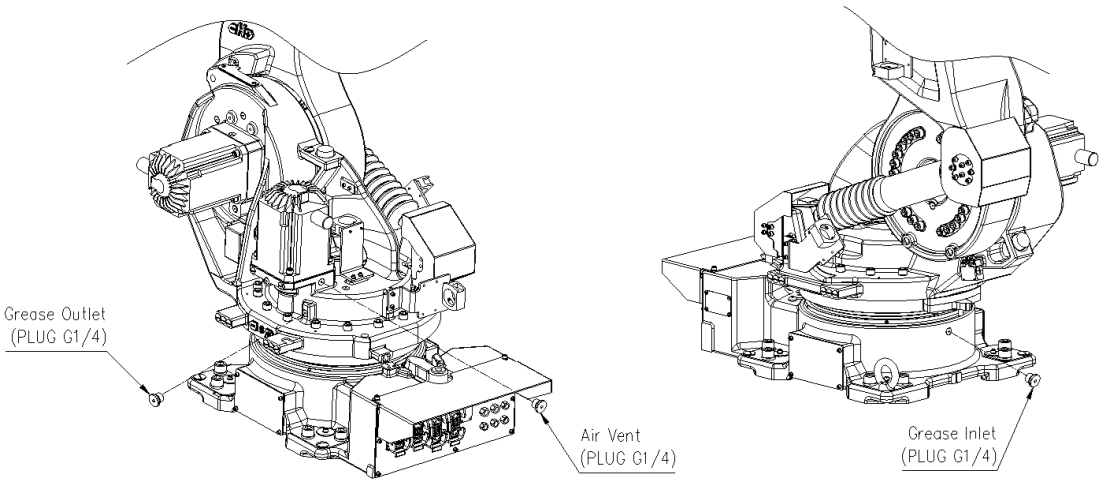


Figure 5.1 S-Axis Reducer Grease Inlet/Outlet

Attention

Injecting grease without removing the plug of the outlet causes an increase of internal pressure and oil leak, and damages a motor because of the inflow of grease.

■ Grease Replacement

(1) Prepare a grease nipple A-PT1/4.

(2) Remove the plug G1/4 of the grease inlet, and fasten the grease nipple A-PT1/4.

(3) Remove the plug G1/4 of the grease outlet and an air vent set, and fasten the plug G1/4 to the air vent set. (The air vent is for the S-axis only.)

(4) Inject the grease into the grease inlet using a grease gun.

✓ **Grease type: VIGO GREASE RE0** ✓ **Amount of grease: 4,000cc (3,600g)**	✓ **Grease type: Eureka 114 NO.0** ✓ **Amount of grease: 4,000cc (3,360g)**

(5) The grease replacement is complete when new grease appears in the outlet port. The new grease can be distinguished from the old one by color.

(6) Move the S-Axis for a few minutes to eject the old grease and then add grease until the new grease appears in the outlet port

(7) Discharge excessively fueled grease and residual pressure. (Refer to the discharge procedure below.)

(8) Remove the grease nipple of the inlet and the plug of the air vent, and assemble the inlet plug and air vent set.

■ Injecting grease after replacing the reducer.

(1) Prepare a grease nipple A-PT1/4.

(2) Remove the plug G1/4 of the grease inlet, and fasten the grease nipple A-PT1/4.

(3) Remove the plug G1/4 of the grease outlet and an air vent set, and fasten the plug G1/4 to the air vent set. (The air vent is for the S-axis only.)

(4) Inject the grease into the grease inlet using a grease gun.

✓ **Grease type: VIGO GREASE RE0** ✓ **Amount of grease: 5,000cc(4,500g)**	✓ **Grease type: Eureka 114 No.0** ✓ **Amount of grease: 5,000cc(4,200g)**

(5) The grease replacement is complete when new grease appears in the outlet port.

(6) Discharge excessively fueled grease and residual pressure. (Refer to the discharge procedure below.)

(7) Remove the grease nipple of the inlet and the plug of the air vent, and assemble the inlet plug and air vent set.

■ Procedure in discharging excessively fueled grease and residual pressure after grease replacement and injection

(1) Attach a grease receiver or a hose to the grease outlet to prevent contamination from discharged grease.

(2) Operate it within a range without surrounding and interference under the following conditions.
① Operation angle : 80° or more
② Operation speed : 50%
③ Operation time: 20 minutes or more

(3) Wipe the outlet port with a cloth and attach the plug.

5.1.2. H-Axis Reducer

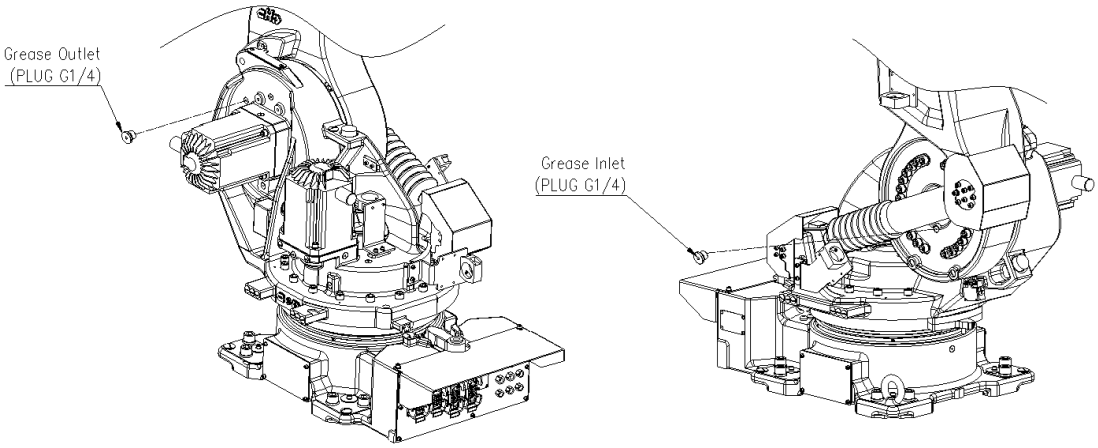


Figure 5.2 H-Axis Reducer Grease Inlet/Outlet

Attention

Injecting grease without removing the plug of the outlet causes an increase of internal pressure and oil leakage and damages a motor because of the inflow of grease.
It is absolutely necessary to remove the plug.

■ Grease Replacement

(1) Prepare the grease nipple A-PT1/4, and then set the H-axis arm perpendicularly. (H:90° -Floor Type, H:0° -Shelf Type)

(2) Remove the plug G1/4 of the grease inlet, and fasten the grease nipple A-PT1/4.

(3) Remove the plug G1/4 of the grease outlet.

(4) Inject the grease into the grease inlet using a grease gun.

✓ **Grease type : VIGO GREASE RE0** ✓ **Amount of grease: 3,466cc (3,120g)**	✓ **Grease type : Eureka 114 No.0** ✓ **Amount of grease: 3,466cc (2,912g)**

(5) The grease replacement is complete when new grease appears in the outlet port. The new grease can be distinguished from the old one by color.

(6) Move the H-Axis for a few minutes to eject the old grease and then add grease until the new grease appears in the outlet port.

(7) Discharge excessively fueled grease and residual pressure. (Refer to the discharge procedure below.)

(8) Remove the grease nipple of the inlet and assemble the inlet plug.

■ Injecting grease after replacing the reducer.

(1) Prepare the grease nipple A-PT1/4, and then set the H-axis arm perpendicularly. (H:90° -Floor Type, H:0° -Shelf Type)

(2) Remove the plug G1/4 of the grease inlet, and fasten the grease nipple A-PT1/4.

(3) Remove the plug G1/4 of the grease outlet.

(4) Inject the grease into the grease inlet using a grease gun.

✓ **Grease type : VIGO GREASE RE0** ✓ **Amount of grease : 4,333cc (3,900g)**	✓ **Grease type : Eureka 114 No.0** ✓ **Amount of grease : 4,333cc (3,640g)**

(5) The grease replacement is complete when new grease appears in the outlet port.

(6) Discharge excessively fueled grease and residual pressure. (Refer to the discharge procedure below.)

(7) Remove the grease nipple of the inlet and assemble the inlet plug.

■ Procedure in discharging excessively fueled grease and residual pressure after grease replacement and injection

(1) Attach a grease receiver or a hose to the grease outlet to prevent contamination from discharged grease.

(2) Operate it within a range without surrounding and interference under the following conditions.
① Operation angle: 90° or more
② Operation speed: 50%
③ Operation time: 20 minutes or more

(3) Wipe the outlet port with a cloth and attach the plug.

5.1.3. V-Axis Reducer

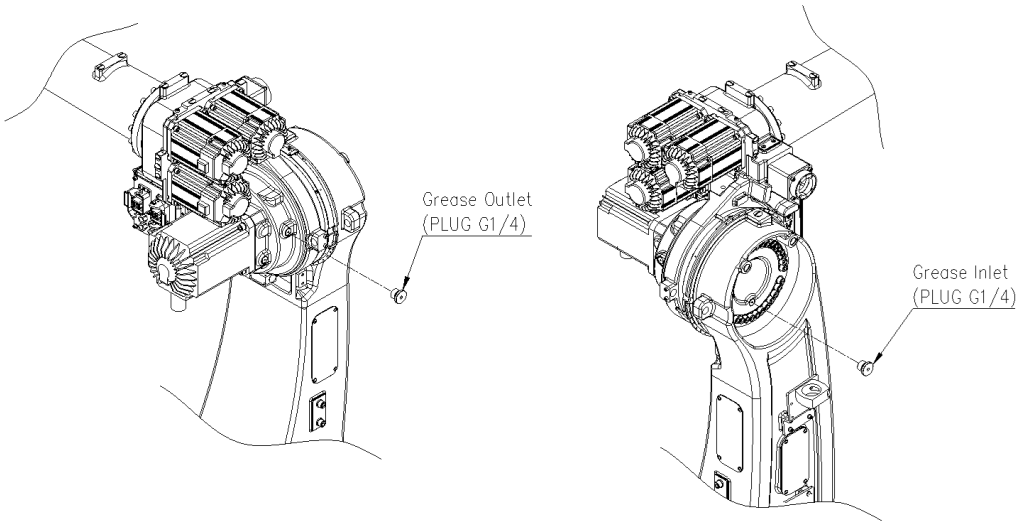


Figure 5.3 V-Axis Reducer Grease Inlet/Outlet

Attention

Injecting grease without removing the plug of the outlet causes an increase of internal pressure and oil leakage and damages a motor because of the inflow of grease. It is absolutely necessary to remove the plug.

■ Grease Replacement

(1) Prepare the grease nipple A-PT1/4, and then set the V-axis arm horizontally.
(V:0° -Floor Type, V:-90° -Shelf Type)

(2) Remove the plug G1/4 of the grease inlet, and fasten the grease nipple A-PT1/4.

(3) Remove the plug G1/4 of the grease outlet.

(4) Inject the grease into the grease inlet using a grease gun.

✓ **Grease type : VIGO GREASE RE0** ✓ **Amount of grease: 2,222cc (2,000g)**	✓ **Grease type : Eureka 114 No.0** ✓ **Amount of grease: 2,222cc (1,866)**

(5) The grease replacement is complete when new grease appears in the outlet port.
The new grease can be distinguished from the old one by color.

(6) Move the V-Axis for a few minutes to eject the old grease and then add grease until the new grease appears in the outlet port.

(7) Discharge excessively fueled grease and residual pressure. (Refer to the discharge procedure below.)

(8) Remove the grease nipple of the inlet and assemble the inlet plug.

■ Injecting grease after replacing the reducer

(1) Prepare the grease nipple A-PT1/4, and then set the V-axis arm horizontally. (V:0° -Floor Type, V:-90° -Shelf Type)

(2) Remove the plug G1/4 of the grease inlet, and fasten the grease nipple A-PT1/4.

(3) Remove the plug G1/4 of the grease outlet.

(4) Inject the grease into the grease inlet using a grease gun.

✓ **Grease type : VIGO GREASE RE00** ✓ **Amount of grease: 2,778cc (2.500g)**	✓ **Grease type : Eureka 114 No.0** ✓ **Amount of grease: 2,778cc (2.333g)**

(5) The grease replacement is complete when new grease appears in the outlet port.

(6) Discharge excessively fueled grease and residual pressure. (Refer to the discharge procedure below.)

(7) Remove the grease nipple of the inlet and assemble the inlet plug.

■ Procedure in discharging excessively fueled grease and residual pressure after grease replacement and injection

(1) Attach a grease receiver or a hose to the grease outlet to prevent contamination from discharged grease.

(2) Operate it within a range without surrounding and interference under the following conditions.
① Operation angle: 70° or more
② Operation speed: 50%
③ Operation time: 20 minutes or more

(3) Wipe the outlet port with a cloth and attach the plug.

5.1.4. R2-Axis Reducer

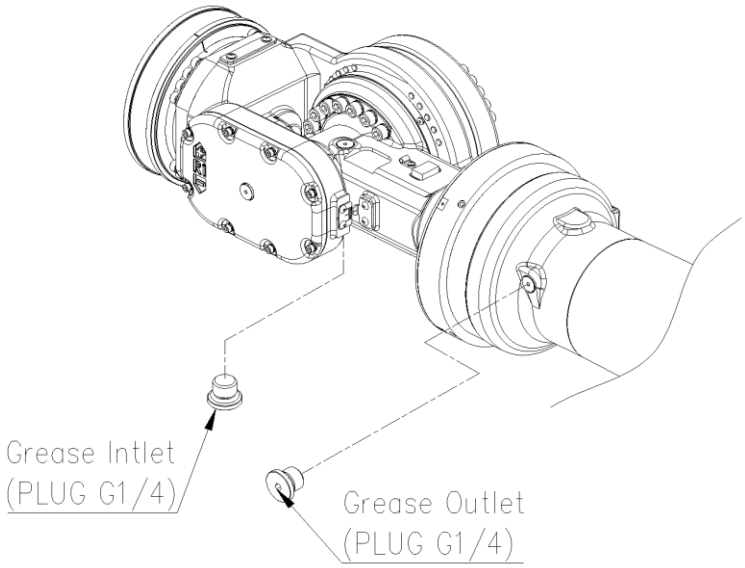


Figure 5.4 R2-Axis Reducer Grease Inlet/Outlet

Attention

Do not inject excessive grease. Excessive amount of grease can cause grease leakage because of an increase of internal pressure and the abnormal operation of the robot.

■ Grease Replacement

(1) Prepare a grease nipple A-PT1/4 and then make the R2-Axis 0°degree.

(2) Remove the plug G1/4 of the grease inlet, and fasten the grease nipple A-PT1/4.

(3) Remove the plug G1/4 of the grease outlet.

(4) Inject the grease into the grease inlet using a grease gun.

✓ **Grease type : VIGO GREASE RE0** ✓ **Amount of grease: 889cc (800g)**	✓ **Grease type : Eureka 114 No.0** ✓ **Amount of grease: 889cc (746g)**

(5) The grease replacement is complete when new grease appears in the outlet port. The new grease can be distinguished from the old one by color.

(6) Move the R2-Axis for a few minutes to eject the old grease and then add grease until the new grease appears in the outlet port.

(7) Discharge excessively fueled grease and residual pressure. (Refer to the discharge procedure below.)

(8) Remove the grease nipple of the inlet and assemble the inlet plug..

■ Injecting grease after replacing the reducer

(1) Prepare a grease nipple A-PT1/4 and then make the R2-Axis 0°degree.

(2) Remove the plug G1/4 of the grease inlet, and fasten the grease nipple A-PT1/4.

(3) Remove the grease outlet plug.

(4) Inject the grease into the grease inlet using a grease gun.

✓ **Grease type : VIGO GREASE RE0** ✓ **Amount of grease: 1,111cc (1,000g)**	✓ **Grease type : Eureka 114 No.0** ✓ **Amount of grease: 1,111cc (933g)**

(5) The grease replacement is complete when new grease appears in the outlet port.

(6) Discharge excessively fueled grease and residual pressure. (Refer to the discharge procedure below.)

(7) Remove the grease nipple of the inlet and assemble the inlet plug.

■ Procedure in discharging excessively fueled grease and residual pressure after grease replacement and injection

(1) Attach a grease receiver or a hose to the grease outlet to prevent contamination from discharged grease.

(2) Operate it within a range without surrounding and interference under the following conditions.
① Operation angle: 60° or more
② Operation speed: 100%
③ Operation time: 20 minutes or more

(3) Wipe the outlet port with a cloth and attach the plug

5.1.5. B-Axis Reducer

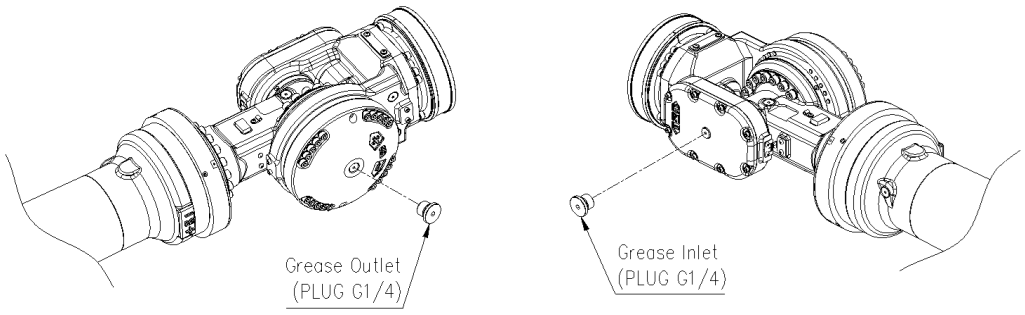


Figure 5.5 B-Axis Reducer Grease Inlet/Outlet

Attention

Do not inject excessive grease. Excessive amount of grease can cause grease leakage because of an increase of internal pressure and the abnormal operation of the robot.

- Grease Replacement

(1) Prepare a grease nipple (A-PT1/4) and then make the R2, B-Axis 0°degree.

(2) Remove the plug G1/4 of the grease inlet, and fasten the grease nipple A-PT1/4.

(3) Remove the plug G1/4 of the grease outlet.

(4) Inject the grease into the grease inlet using a grease gun.

✓ **Grease type : VIGO GREASE RE0** ✓ **Amount of grease: 1,200cc(1,080g)**	✓ **Grease type : Eureka 114 No.0** ✓ **Amount of grease: 1,200cc(1,008g)**

(5) The grease replacement is complete when new grease appears in the outlet port. The new grease can be distinguished from the old one by color.

(6) Move the B-Axis for a few minutes to eject the old grease and then add grease until the new grease appears in the outlet port.

(7) Discharge excessively fueled grease and residual pressure. (Refer to the discharge procedure below.)

(8) Remove the grease nipple of the inlet and assemble the inlet plug.

■ Injecting grease after replacing the reducer

(1) Prepare a grease nipple A-PT1/4 and then make the R2, B-Axis 0°degree.

(2) Remove the plug G1/4 of the grease inlet, and fasten the grease nipple A-PT1/4.

(3) Remove the grease outlet plug.

(4) Inject the grease into the grease inlet using a grease gun.

✓ **Grease type : VIGO GREASE RE0** ✓ **Amount of grease: 1,500cc (1,350g)**	✓ **Grease type : Eureka 114 No.0** ✓ **Amount of grease: 1,500cc (1,260g)**

(5) The grease replacement is complete when new grease appears in the outlet port.

(6) Discharge excessively fueled grease and residual pressure. (Refer to the discharge procedure below.)

(7) Remove the grease nipple of the inlet and assemble the inlet plug.

■ Procedure in discharging excessively fueled grease and residual pressure after grease replacement and injection

(1) Attach a grease receiver or a hose to the grease outlet to prevent contamination from discharged grease.

(2) Operate it within a range without surrounding and interference under the following conditions.
① Operation angle: B-axis, 120° or more
② Operation speed: 100%
③ Operation time: 20 minutes or more

(3) Wipe the outlet port with a cloth and attach the plug.

5.1.6. R1-Axis Reducer

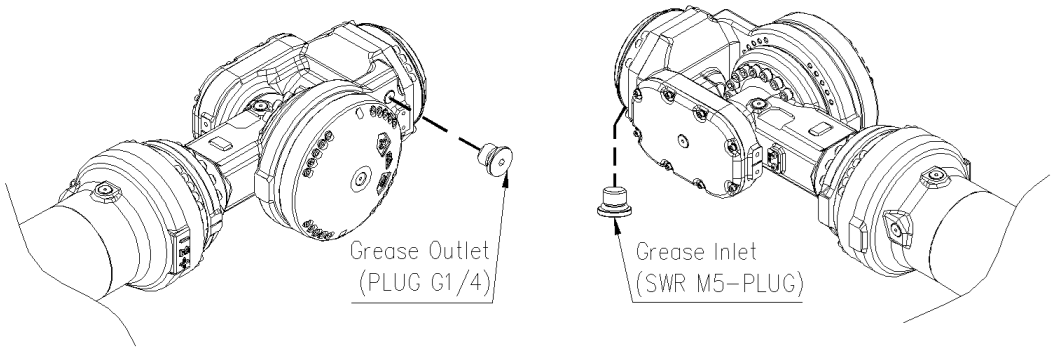


Figure 5.6 R1-Axis Reducer Grease Inlet/Outlet

Attention

Do not inject excessive grease. Excessive amount of grease can cause grease leakage because of an increase of internal pressure and the abnormal operation of the robot.

- Grease Replacement

(1) Prepare a grease nipple (A-PT1/4) and then make the R2, B and R1-Axis 0°degree.

(2) Remove the plug SWR-M5 of the grease inlet, and fasten the grease nipple A-PT1/4.

(3) Remove the plug G1/4 of the grease outlet.

(4) Inject the grease into the grease inlet using a grease gun.

✓ **Grease type : VIGO GREASE RE0** ✓ **Amount of grease: 178cc (160g)**	✓ **Grease type : Eureka 114 No.0** ✓ **Amount of grease: 178cc (150g)**

(5) The grease replacement is complete when new grease appears in the outlet port. The new grease can be distinguished from the old one by color.

(6) Move the R1-Axis for a few minutes to eject the old grease and then add grease until the new grease appears in the outlet port.

(7) Discharge excessively fueled grease and residual pressure. (Refer to the discharge procedure below.)

(8) Remove the grease nipple of the inlet and assemble the inlet plug.

■ Injecting grease after replacing the reducer

(1) Prepare a grease nipple (A-PT1/4) and then make the R2, B and R1-Axis 0°degree.

(2) Remove the plug SWR-M5 of the grease inlet, and fasten the grease nipple A-PT1/4.

(3) Remove the grease outlet plug.

(4) Inject the grease into the grease inlet using a grease gun.

✓ **Grease type : VIGO GREASE RE0** ✓ **Amount of grease: 222cc (200g)**	✓ **Grease type : Eureka 114 No.0** ✓ **Amount of grease: 222cc (187g)**

(5) The grease replacement is complete when new grease appears in the outlet port.

(6) Discharge excessively fueled grease and residual pressure. (Refer to the discharge procedure below.)

(7) Remove the grease nipple of the inlet and assemble the inlet plug.

■ Procedure in discharging excessively fueled grease and residual pressure after grease replacement and injection

(1) Attach a grease receiver or a hose to the grease outlet to prevent contamination from discharged grease.

(2) Operate it within a range without surrounding and interference under the following conditions.
① Operation angle: 60° or more
② Operation speed: 100%
③ Operation time: 20 minutes or more

(3) Wipe the outlet port with a cloth and attach the plug.

5.1.7. Arm Frame - Gear Box

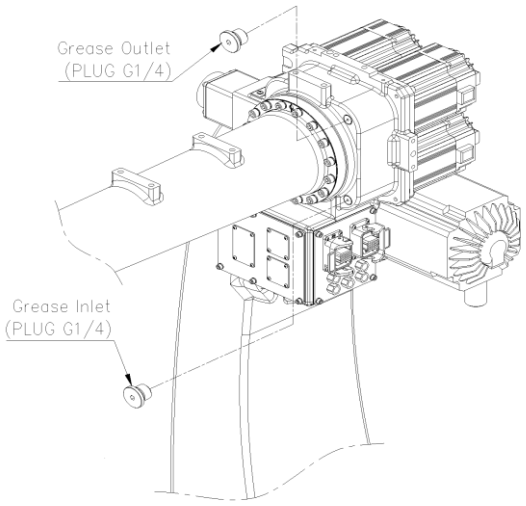


Figure 5.7 Arm Frame Grease Inlet/Outlet

- Grease Replacement

(1) Prepare the grease nipple A-PT1/4, and then set the V-axis arm horizontally. (V:0° -Floor Type, V:-90° -Shelf Type)

(2) Remove the plug G1/4 of the grease inlet, and fasten the grease nipple A-PT1/4.

(3) Remove the plug G1/4 of the grease outlet.

(4) Inject the grease into the grease inlet using a grease gun.

- ✓ **Grease type : GADUS S2 V46 2**
- ✓ **Amount of grease : 500cc (450g)**

(5) The grease replacement is complete when new grease appears in the outlet port. The new grease can be distinguished from the old one by color.

(6) Move the V-Axis for a few minutes to eject the old grease and then add grease until the new grease appears in the outlet port.

(7) Discharge excessively fueled grease and residual pressure. (Refer to the discharge procedure below.)

(8) Remove the grease nipple of the inlet and assemble the inlet plug.

- Procedure in discharging excessively fueled grease and residual pressure after grease replacement and injection

  (1) Attach a grease receiver or a hose to the grease outlet to prevent contamination from discharged grease.

  (2) Operate it within a range without surrounding and interference under the following conditions.
  ① Operation angle: R-axis, 60° or more / B-axis, 120° or more / R1-axis, 60° or more
  ② Operation speed: 100%
  ③ Operation time: 20 minutes or more

  (3) Wipe the outlet port with a cloth and attach the plug.

5.1.8. Gas Spring Bearing

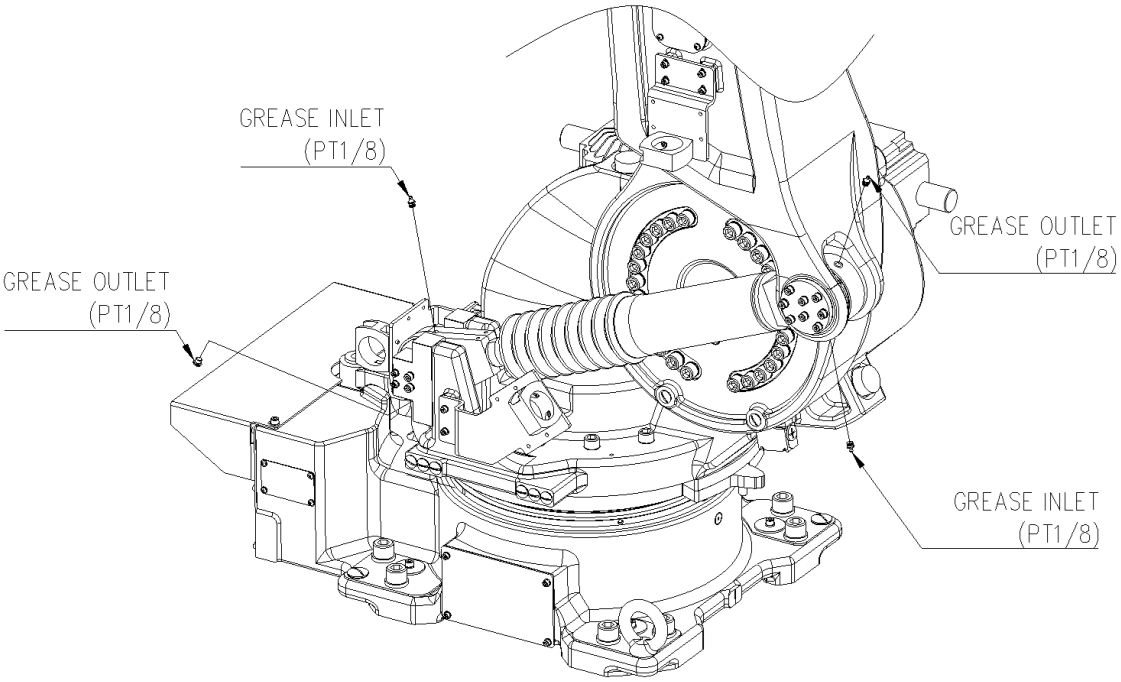


Figure 5.8 Gas Spring Grease Inlet/Outlet (Opening of cover)

- Grease Injection Method

(1) Open the nipple PT1/8 in the back of outlet and grease it through the nipple PT1/8 in the back of inlet. (Air pressure 5~7kg/cm^2, Decompression is not needed.)

- ✓ **Grease type: GADUS S3 V220C 2**
- ✓ **Initial amount of grease injection : 15cc (13.5g)**
- ✓ **Amount of grease refueling : 7cc (6.3g)**

(2) Inject grease through the grease nipple until the new grease is squeezed out from the gap between the Nilos ring and the bearing in 360° direction of the bearing.

(3) Clean up discharged grease caused by excessive fueling with a cloth.

(4) Clean the inlet and outlet using a cloth and reassemble the nipple on the side of outlet.

5.2. Battery Replacement

The position data of each axis is preserved by the backup batteries. The batteries need to be replaced every two years. To replace batteries observe the following procedure.

(1) Keep the power on. Press the Emergency Stop button to prohibit the robot motion.

Attention

Replacing the batteries with the power supply turned off causes all current position data to be lost. Therefore, zeroing will be required again.

(2) Detach the battery cover.

(3) Take out the old batteries from the battery cover.

(4) Insert new batteries into it. Pay attention to the direction of batteries.

- ✓ **Battery Spec. : ER6V-T1 (AA) 3.6V**
- ✓ **Manufacturer : TOSHIBA**

(5) Reinstall the battery cover.

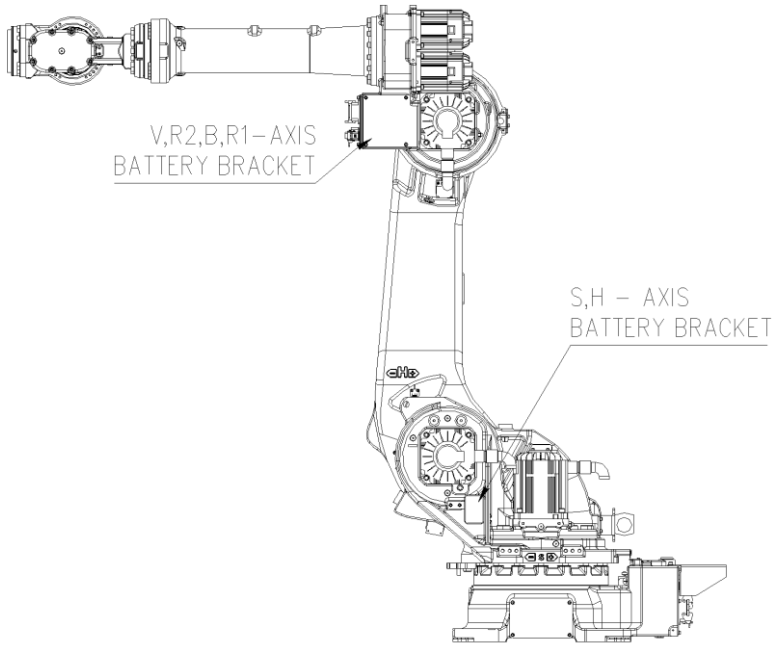


Figure 5.9 Location of Battery Replacement

Attention

- ✓ **Do not dispose the batteries. Dispose of the battery with industrial waste according to the laws and other rules in the country where the controller is installed.**
- ✓ **Do not recharge the batteries, otherwise batteries may result in exploding or overheating.**
- ✓ **Do not use any batteries other than the recommended one.**
- ✓ **Change the batteries only with the specified one.**
- ✓ **Do not short positive and negative terminals of battery.**
- ✓ **Do not expose batteries to high temperature or flame**

5.3. Internal Wiring

Replacement cycle of internal wiring depends on follows.

- Continuous operation
- Operating speed
- Atmosphere/environment

Inspect on a regular basis, every three months and check any damage on the cables or cable protect spring. If any damage, replace it.

Replace the cable every 24,000 operating hours regardless of working condition.

Attention

- ✓ **As all the wires are flexible type, do not use any wires other than specified one.**
- ✓ **Wiring replacement must be done by unit.**
- ✓ **Do not use any Cable, protective spring, and Hose that have external damage as they may cause future problems.**
- ✓ **When purchasing robot cables, make inquiry of our service office about wiring type.**
- ✓ **Specify the length of wiring for connecting the robot with the controller.**

6
Troubleshooting

6.1. Troubleshooting Procedure

If a failure occurs during robot's operation, but it does not stem from the controller, it must be caused by damage on machine parts. The way to troubleshoot as quick and easy as possible should be to diagnose the problem. In addition, it is necessary to determine which parts cause the problem.

(1) Step 1: Which axis occurs the problem?
First of all, check which axis causes the malfunction. In case that it is hard to detect the problem, check the following possible mechanical defaults.

- Is there any parts making noise?
- Is there any parts generating an overheating?
- Is there any parts have a play or backlash?

(2) Step 2: Which parts have been damaged?
If the abnormal axes are determined, investigate which parts cause trouble. There could be many causes for one phenomenon. Refer to [Table 6-1] for the cause and phenomenon of the trouble.

(3) Step 3: Dealing with malfunction parts
If the malfunction parts are confirmed, conduct relevant repair procedure based on the chapter 『6.3 Diagnostics and Resolutions for Major Parts Failure』. Contact our service office if you have any difficulties in dealing with problems.

6.2. Trouble Symptoms and Possible Causes

As shown in [Table 6-1], there may be many parts as the cause of one phenomenon.
Refer to next page to determine which part is malfunction.

Table 6-1 Trouble phenomenon and cause

Location of abnormality / Symptoms of the trouble	Reducer	Brake	Motor	Encoder	Backlash	Grease	Gas spring
Overloaded [Note 1]	○	○	○				○
Position deviated	○	○	○	○			○
Abnormal sound generated	○	○	○			○ [Note 3]	○
Vibration during operation [Note 2]	○		○			○ [Note 3]	
Trajectory deviated	○			○			○
Axis freefalling	○	○					○
Abnormal heating	○	○	○	○			
False operation, runaway				○			

[Note 1] Overloaded -------- A phenomenon that occurs when a load exceeding the conditions of the rated specification of the motor is applied.
Specifically, it occurs when the temperature relay or circuit breaker is cut off.
[Note 2] Vibration during operation ------- Vibration that occurs during operation.
[Note 3] If an abnormal sound is generated in the reducer part during operation at low speed, check the condition for 1 to 2 days while performing operation. The abnormal sound usually disappears.
It can be checked that the abnormal sound will disappear even when the concerned axis is operated at high speed for about 5 to 10 minutes or more.
When the old grease is discharged as much as possible (about 90% or more) and replaced with new grease, abnormal grease sound can be minimized (When the grease is discharged while the axis is rotating at low speed, the grease discharge time can be shortened.)

Abnormal sound usually occurs in the following cases:

1. During operation after replacement of grease/reducer
2. During operation after a long-term non-operation
3. During operation at low speed
4. During operation at low temperature
5. When using unspecified grease
6. Mixing of grease of different specifications

6.3. Diagnostics and Resolutions for Major Parts Failure

6.3.1. Reducer

Warning

- ✓ **When required to replace the motor and reducer of the H axis and V axis, you must fix the arm with a fall-prevention bolt or pin before the work so that the arm does not fall when the brake release switch is turned "On" and "Off."**
- ✓ **When required to replace the motor and reducer of the R2 axis, B axis, and R1 axis, you should move the robot into a posture where the tool does not rotate and fall when the brake release switch is turned "On" and "Off."**
- ✓ **To prevent accidents because of falling of the axis, you must check whether the pressure of the gas spring is appropriate before the work. The H axis may fall when the robot operates at a pressure lower than the appropriate working pressure.**

If the reducer is damaged, phenomena such as vibration and abnormal sound will appear. In this situation, abnormalities such as overload and deviation that will interfere with normal operation can be caused, and abnormal heating may occur. Also, there are cases where the robot does not move at all or a position deviation occurs.

When required to replace the reducer, you must fix the arm with a fall-prevention bolt or pin before the work so that the arm does not fall.

- Investigation method

  ① Investigate whether there is any vibration, abnormal sound, abnormal heating, an error because of motor overload, etc. during the operation.
  ② Investigate whether there is any abnormal sound, tool overload, delay in replacement of grease, etc.
  ③ Investigate whether the robot has come into contact with or collided with a peripheral system.
  (there are some cases where the reducer is damaged because of a contact-induced impact.)

- Handling method

  ① When it is judged to be the abnormal grease sound, operate the relevant axis at high speed until the grease sound disappears.
  If the abnormal sound does not disappear even after operating the axis at high speed for a long time, you should discharge the existing grease as much as possible and then inject new grease.
  ② Take measures to prevent tool overload, interference or collision with surroundings.
  ③ It is necessary to replace the reducer in the case of use in an overloaded state, collision, presence of foreign substances inside the reducer, or when grease has not been replaced for a long time. If you have any difficulty in replacing the reducer, please contact our service department.

6.3.2. Brakes

In case of brakes failure, each axis possibly drops with the motors [OFF]. Or, in reverse, brakes possibly operate even with the motors [ON]. The latter causes overload and noise

When intending to operate the entire robot without the motors [ON], operate it with the brake release switch [ON]. Before turning the switch [ON], take necessary precautions to prevent the ARM from dropping as the robot ARM will drop by gravity

- Diagnostics

  Check if the brake can be heard in operation, by turning the brake release switch [ON] [OFF] alternately with the motors [OFF]. If not heard, the brake cable may be broken. (When operating the brake release switch [ON][OFF], be careful of ARM dropping. The brake release switch is located on the panel in the controller cabinet door.)

- Resolution

  If cables turn out to be good condition, replace the motor

6.3.3. Motor

Motor failure causes abnormal operation of robot such as staggering at stop, irregular twitching and noise in operation. Besides, it may cause overheating and abnormal sound

Check the reducer and fulcrum bearing as well in order to determine which part causes the abnormality. It is because that similar phenomenon is observed when the reducer is damaged

- Diagnostics

  Check for overheating and abnormal sound

- Resolution

  Replace the motor

6.3.4. Encoder

Position offset, malfunction, and out of control movement as well as staggering at stop, irregular twitching may occur when the Encoder is in bad condition. This case has nothing to do with such phenomena as mechanical abnormal sound, overheating, and vibration

- Diagnostics

  ① Check for any encoder data failure
  ② Use reference pins and blocks to check the positional data is correct at pin position
  ③ Check for any irregular variations in the encoder data when moving each robot axis
  ④ Replace the servo amp board, BD542 to check errors

- Resolution

  ① If cabling turns out to be in good condition without any damage, replace the encoder
  ② If there is no error after replacing the servo amp board BD542, replace the servo amp board

6.3.5. Gas Spring

If the pressure of the gas spring drops excessively, it may cause abnormal heating and overloading in the motor or cause the arm to fall.
Fill nitrogen gas so that the pressure does not drop more than 5 bar below the reference pressure.

Periodically inject grease into the upper and lower bearings of the gas spring to prevent the bearings from being damaged.

Before checking the gas spring, you must ensure that the controller and external power are in the 『OFF』 state. Also, take measures to prevent the controller and external power from being accidently turned 『ON』 by someone else.
You must wear protective glasses when checking the gas pressure.

- Investigation method

  ① Check whether the pressure of the gas spring is appropriate.
  ② Check if powder is generated because of grinding in the bearing part of the gas spring.
  ③ If grease has not been injected into the bearing for a long time, you should operate the robot to check if there is any abnormal vibration.

- Handling method

  ① Fill nitrogen gas so that the pressure of the gas spring reaches 140 bar.
  ② Replace the gas spring with new one when its pressure drops within a short period of time after the filling of nitrogen gas, or when the gas spring has been in operation for a long time at low pressure.
  ③ Fill the grease in the bearing part.
  ④ Replace the bearing if it is abnormal.
  ⑤ If you have any difficulties with the handling method, please contact our service department.
  ⑥ For replenishing the gas, refer to the “Replenishing the Gas in the Gas Spring” section.
  ⑦ For the pressure criteria and replacement, refer to the “Replacing the Gas Spring” section.

Warning

- ✓ Keep the appropriate working pressure of the gas spring to prevent the arm from falling.
- ✓ Periodically inject grease into the bearing to prevent early damage to the bearing.

6.4. Motor Replacement

Warning

When motor is separated, the ARM will drop due to its built-in brakes inside the motor for holding robot's posture. To prevent this drop, please make sure safety measures, such as suspending the arm with devices like a crane, etc., or fixing the 1st arm and the 2nd arm with fixing pins, are employed

In case of contacting the motor right after it stops, ensure the motor temperature. Motor weights are listed as follows. Be careful when dealing with the motor

Table 6-2 Motor Weight by Axis

Axis	S	H	V	R2	B	R1
Weight(kg)	26.1	26.1	26.1	11.9	11.9	11.9

Warning

In this work, there is a part performed with the motor [ON]. Therefore, perform the work in pairs. An observer must always be ready to activate an emergency stop. The other performs the work quickly and carefully. An escape route should be determined before starting work

6.4.1. Necessary Tools and Parts

Table 6-3 Necessary Tools

Tool Name	Axis Name	Part No.(Model)	Remark
Torque wrench (prepared by user)	S, H, V	M8 Torque wrench (Lock type) M12 Torque wrench(Lock type)	Use torque wrench and extension on the market
	R2, B, R1	M8 Torque wrench (Lock type) M6 Torque wrench (Lock type)	

Table 6-4 Necessary parts

Part Name	Axis Name	Use or not	Part No.(Model)
Dropping preventive bolt (optional)	Axis H, V	○	M20×250(Standard)
	Wrist (R2, B, R1)	-	-

(When overhauling the robot, a leveling bulb can be used to focus on the precise starting point. To focus on the precise starting point, please contact us.)

6.4.2. How to Replace Motor

Warning

Because a brake for maintaining the posture of the arm is embedded in the motor of the robot, the arm will fall if the motor is separated. Thus, to prevent falling, there must be safety measures such as hanging the arm using a crane and then inserting fixing bolts to fix arm 1 and arm 2.

(1) Put the controller into TEACH mode and select motors [ON]. When the motors [On] state cannot be obtained, check the respective ARM is firmly fixed while supporting it to prevent dropping. And then begin at step No.4

(2) The axis requiring motor replacement takes basic posture

(3) In case of main axes(S, H, V): Refer to [Figure 6.1] and [Figure 6.4]
In case of wrist axes H, V Insert a supporting bolt to prevent ARM dropping
In case of wrist axes (R2, B, R1): Set the origin by using SCALES

(4) Turn the main power [OFF] with the controller power [OFF]

(5) Disconnect the connector from the motor

(6) Remove attachment bolts of motor and pull the motor out of robot. When removing motors of axis H or V, be sure not to damage the lip of oil seal due to the gear attached to the axis of motor

(7) Detach the gear from the motor shaft. Not give excessive impact to the motor shaft

(8) Assemble the gear after lightly applying grease to the shaft
The bolt used to attach the gear to the shaft should be cleaned and removed of grease before using. Apply Loctite 243 to the screw part of the bolt, and then tighten it using a torque wrench in a regular torque. Besides, slowly tighten the bolt in a symmetrical order

(9) Assemble the motor on the robot after applying a small amount of grease to the lip of oil seal and applying a moderate amount of grease to the teeth of gear. When assembly the main axis motor, be sure not to damage the lip of oil seal

(10) Connect the connector to the motor

(11) When replacing the axis H or V, replenish the grease as the amount as it lost

(12) Reset the encoder of the axis whose motor is replaced

Warning
Before encoder correction, check motor connections, with motors [ON], while pressing the Enable switch for 2~3 seconds.

(13) Perform the encoder calibration about the axis whose motor is replaced. Refer to the chapter [Encoder Calibration] in the controller operating manual.

(14) Remove M20 bolt, a supporting bolt for preventing possible dropping of axis H, V.

(15) Confirm that there is no error in robot's motion.

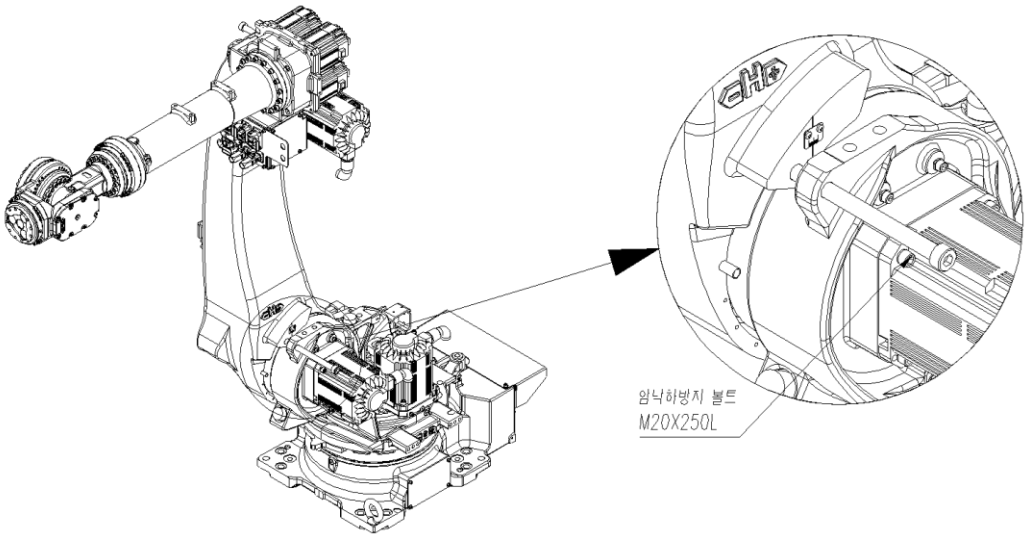


Figure 6.1 Insertion position of Arm 1 (H axis) fixing bolt

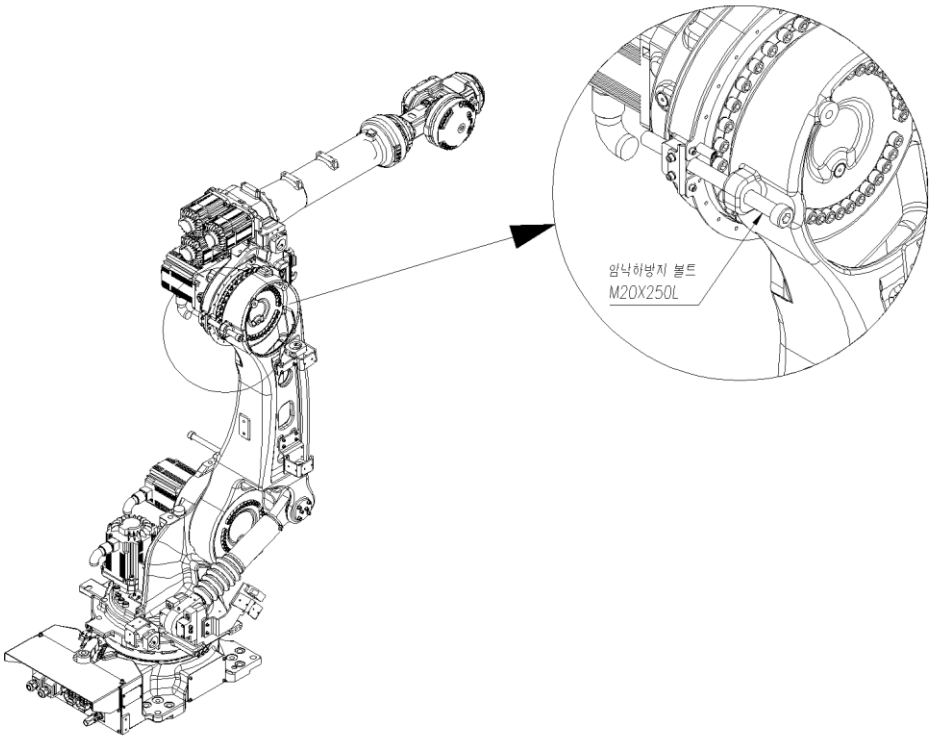


Figure 6.2 Insertion position of Arm 2 (V axis) fixing bolt

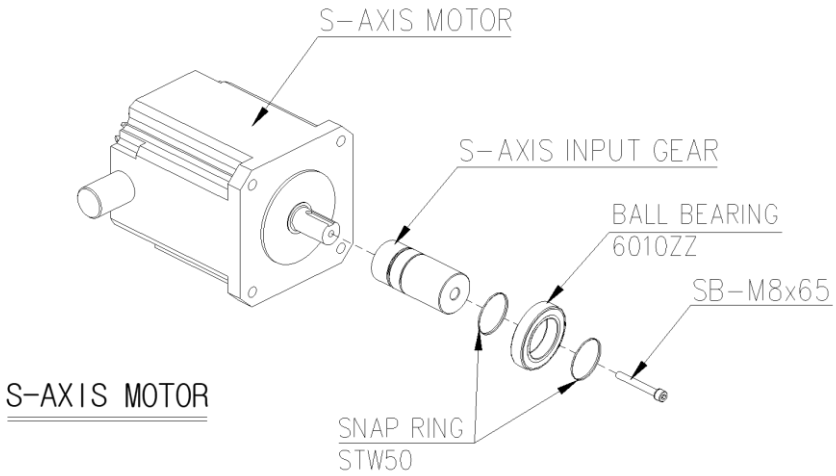


Figure 6.3 Axis S motor assembly

Caution

If the entire upper arm is not completely attached to the mechanical stopper in a gravitational direction when replacing the motor of the V-axis, the upper arm may rotate when the motor is being dismantled.

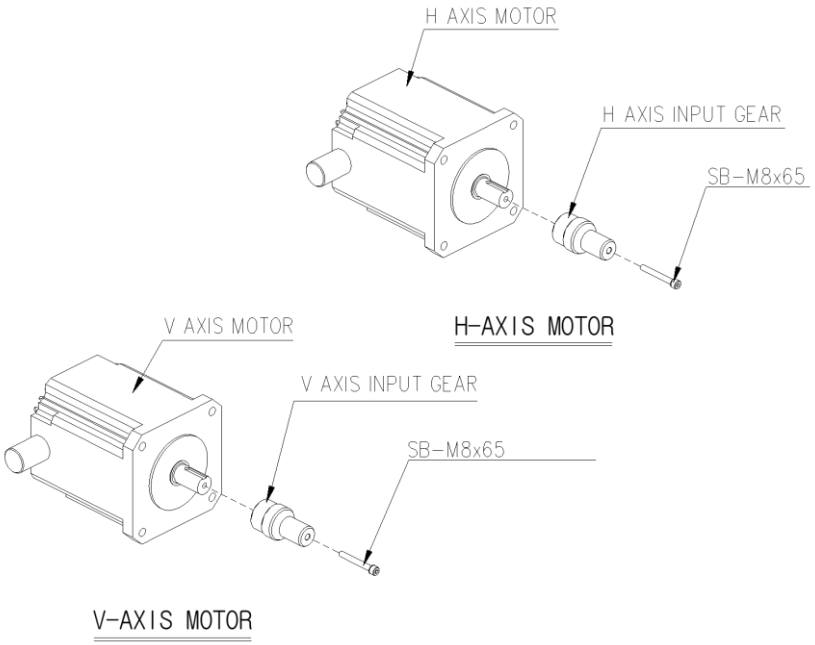


Figure 6.4 Axis H&V Motor Assembly

Caution

If the entire upper arm is not completely attached to the mechanical stopper in a gravitational direction when replacing the motor of the V-axis, the upper arm may rotate when the motor is being dismantled.

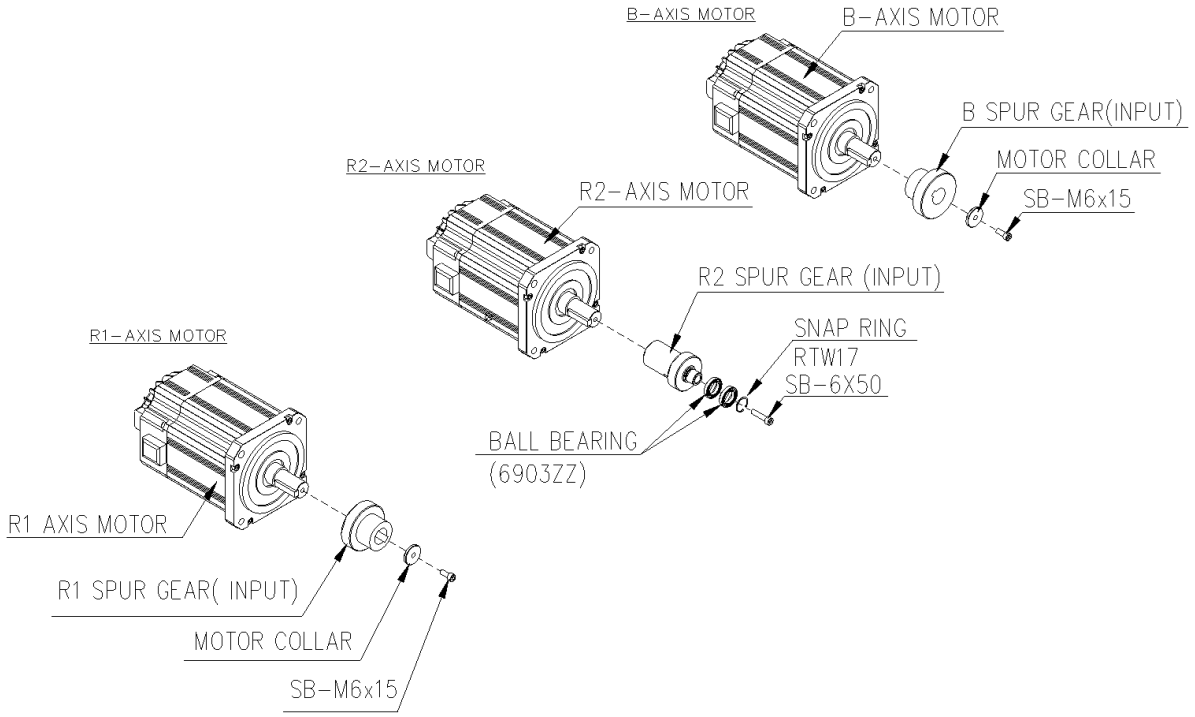


Figure 6.5 Wrist Axis Motor Assembly

6.5. Encoder Zero Setting

It is necessary to reset the origin when encoder data has been corrupted due to some problems and when the motor is replaced.

Scale is used for deciding the location of the reference position of each axis of the robot. When the user replaces the motor, set the encoder using the scale to set the zero point of each axis.

Warning

In this work, there is a part performing in the state of motor [ON]. Therefore, this work must be performed in pairs. One must always be ready to activate an emergency stop. The other must perform the work quickly but carefully
An escape route should be determined before starting work

6.5.1. Zero Setting

(1) Put the controller into TEACH mode and select [MOTOR ON].
If you cannot select MOTOR On due to abnormality, set the origin position of the robot by using the brake release switch.

(2) Move respective axes to the basic posture, and then set them by the scale mark.

(3) Reset the Encoder. Refer to 『6.5.2 Encoder Reset』for the method of encoder reset.

(4) Correct the encoder. Refer to 『Controller Operation Manual “7.5.4 Serial encoder reset”』.

(5) Confirm that there is no problem in robot motion.

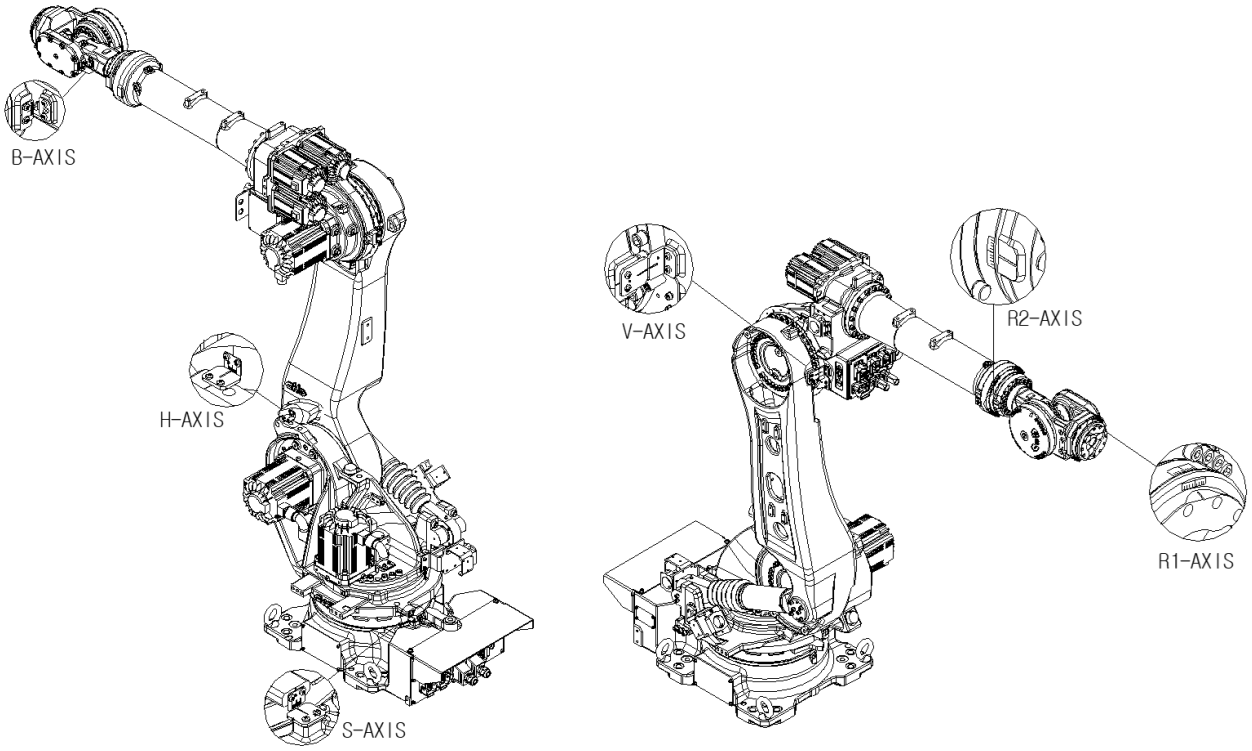
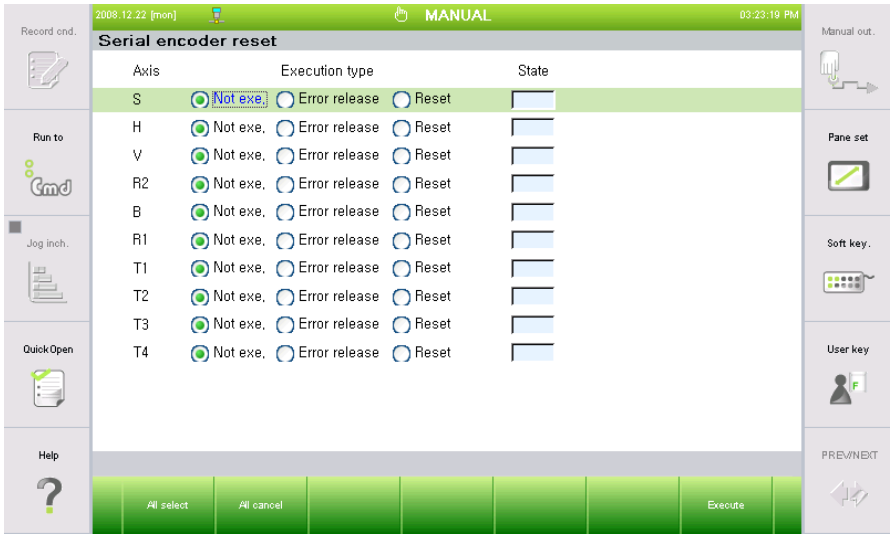


Figure 6.6 Method of Zero Setting

6.5.2. Encoder Reset

(1) Turn off the motor.

(2) Open the serial encoder reset window. (『[F2]: System』 → 『5: Initialize』 → 『4: Serial encoder reset』)



(3) Use keys like [↓], [↑], [SHIFT]+[←][→] to move to a desirable axis, then press the [Execute] key.

(4) After the encoder is reset, please make sure the controller power is turned on.

6.5.3. Encoder offset and Selection

- It is necessary to compensate encoder data for the basic position of each axis.
- Refer to 『Encoder offset』 in the Controller Manual for details.

[Encoder offset Screen]

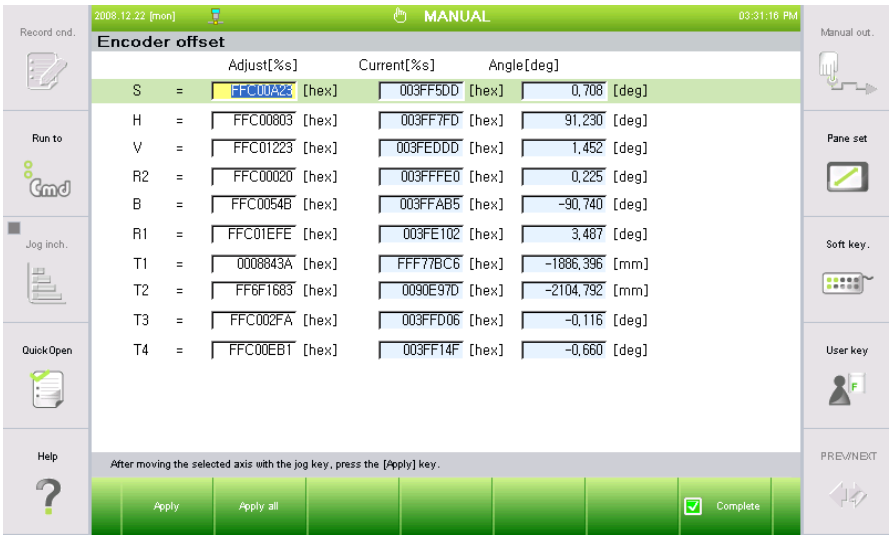


Table 6-5 Data range after resetting

Axis	Data range after resetting	Number of pulses per an encoder revolution
All of Axes	0 ~ 8,191	8,192

(1) Select the axis, move the axis to a standard position using the [Axis operation] key, and press the 『[F1]: Apply』 key.

(2) Place the robot's entire axis as the standard position using the [Axis operation] key and press the 『[F2]: Apply all』 key to carry out encoder offset correction for the entire axis.

(3) To save the set data, press the 『[F7]: Complete』 key. The [ESC] key will prevent the changes being saved.

Warning

In case of encoder DATA compensation after replacing motor, check if the motor power is on with the power 『ON』.

7
Recommended Spare Parts

The recommended spare parts for robot are as follows. Please check robot serial number and manufacturing date when purchasing, and contact our service office.

[Category]
A : Regular maintenance parts(what is replaced regularly)
B : Essential spare parts (what is of high frequency)
C : Essential component parts
D : Machine parts

Table 7-1 Spare Parts List

Category	Robot Applied	PLATE No.	Product Name and Specification	Quantity	Remark
A	HC165L HC200	R7900004400	GREASE VIGO GREASE 1CAN=16KG	1	Common
A	HC165L HC200	R7900054780	GREASE GADUS (1CAN=15KG)	1	Common
A	HC165L HC200	R1000-6103-033	ENCODER BATTERY	6	Common
B	HC165L HC200	R3224-7112-P01	MOTOR	1	S-Axis
B	HC165L HC200	R3224-7212-P01	MOTOR	2	H/V-Axis
B	HC165L HC200	R3224-7312-P01	MOTOR	3	R2/B/R1-Axis
B	HC165L HC200	R3224-7112-P02	REDUCER	1	For S-axis INPUT GEAR
B	HC165L HC200	R3224-7212-P02	REDUCER	1	For H-axis INPUT GEAR
B	HC165L HC200	R3224-7212-P04	REDUCER	1	V-Axis
B	HC165L HC200	R3224-7312-P02	REDUCER	1	R2-Axis
B	HC165L HC200	R3224-7412-P01	REDUCER	1	B-Axis
B	HC165L HC200	R3224-7412-P02	REDUCER	1	R1-Axis
C	HC165L HC200	R3224-7412-001	WRIST ASSY	1	WRIST ASSY
C	HC165L HC200	R3224-7212-113	INPUT GEAR(V)	1	For V-axis Motor
C	HC165L HC200	R3224-7312-137	R2 SPUR GEAR(INPUT)	1	For R2-axis Motor
C	HC165L HC200	R3224-7312-139	R1 AND B SPUR GEAR(INPUT)	2	For B/R1-axis Motor
C	HC165L HC200	R3224-7512-002	CABLE ASSY	1	CABLE ASSY

Category	Robot Applied	PLATE No.	Product Name and Specification	Quantity	Remark
A	HC165L HC200	R3224-7230-001	GAS SPRING&BS JOINT& ELLOWS(COVER)	1	For gas spring
C	HC165L HC200	R3224-7230-P04,P05	BELLOWS(COVER) FOR GAS SPRING	1	For gas spring
D	HC165L HC200	R3224-7112-P04	BALL BEARING	1	For S-axis CENTER GEAR
D	HC165L HC200	R3224-7112-P05	BALL BEARING	1	For S-axis INPUT GEAR
D	HC165L HC200	R3224-7212-P05	OIL SEAL	2	For H/V-axis INPUT GEAR
D	HC165L HC200	R3224-7312-P11	BALL BEARING	2	For R2 SPUR GEAR
A	HC165L HC200	R3224-7230-R02	PRESSURE TESTER (for gas spring pressure measurement)	1	Option (For gas spring)
A	HC165L HC200	R3224-7230-R04	GAS BOOSTER KIT - Apply if a nitrogen gas bottle is 150 bars or less - Included item when ordering: optional gas bottle joint screw	1	Option (For gas spring)
A	HC165L HC200	R3224-7230-R06	REPLENISHING ARMATURE KIT - Apply if a nitrogen gas bottle is 150 bars or more - Included item when ordering: optional gas bottle joint screw	1	Option (For gas spring)
D	HC165L HC200	R3224-7230-P02	Spherical Bearing	2	For gas spring
D	HC165L HC200	R3224-7230-P03	Nilos Ring	4	For gas spring
D	HC165L HC200	R3224-7112-P09	O-RING	1	For S-axis reducer
D	HC165L HC200	R3224-7112-P10	O-RING	1	For S-axis reducer
D	HC165L HC200	R3224-7212-P09	O-RING	1	For H-axis reducer
D	HC165L HC200	R3224-7212-P10	O-RING	1	For H-axis reducer
D	HC165L HC200	R3224-7212-P07	O-RING	1	For V-axis reducer
D	HC165L HC200	R3224-7212-P08	O-RING	1	For V-axis reducer

Category	Robot Applied	PLATE No.	Product Name and Specification	Quantity	Remark
D	HC165L HC200	R3224-7312-P17	O-RING	1	For R2-axis reducer
A	HC165L HC200	R3224-7230-P06	FILTER UNIT	1	For gas spring
B	HC165L HC200	R3224-7412-001	WRIST ASSY	1	WRIST ASSY
D	HC165L HC200	R3224-7412-P11	O-RING	1	For B-axis reducer
D	HC165L HC200	R3224-7412-P12	O-RING	2	For R2/B-axis reducer
D	HC165L HC200	R3224-7412-P10	O-RING	1	For R1-axis reducer
D	HC165L HC200	R3224-7112-P07	O-RING	1	For S-axis Motor
D	HC165L HC200	R3224-7212-P06	O-RING	2	For H/V-axis Motor
D	HC165L HC200	R3224-7312-P15	O-RING	3	For R2/B and R1-axis Motor
D	HC165L HC200	R3224-7230-R07	REPAIR KIT (for separating the internal parts of gas spring)	1	Option (For gas spring)
D	HC165L HC200	R3224-7230-R09	Replacement CARTRIDGE (gas spring)	1	Option (For gas spring)
D	HC165L HC200	R3224-7230-R11	Replacement PISTON ROD (gas spring)	1	Option (For gas spring)
D	HC165L HC200	R3224-7312-P03	BALL BEARING	1	R1-axis SPLINE SHAFT
D	HC165L HC200	R3224-7312-P04	BALL BEARING	1	R1-axis SPLINE SHAFT
D	HC165L HC200	R3224-7312-P05	BALL BEARING	1	B-axis PIPE
D	HC165L HC200	R3224-7312-P06	BALL BEARING	1	R2-axis PIPE
D	HC165L HC200	R3224-7312-P07	BALL BEARING	1	R1-axis SPLINE SHAFT
D	HC165L HC200	R3224-7312-P08	BALL BEARING	1	B-axis SPLINE SHAFT
D	HC165L HC200	R3224-7312-P09	BALL BEARING	1	R2-axis INPUT GEAR
D	HC165L HC200	R3224-7312-P10	BALL BEARING	2	R1-axis SPLINE SHAFT
D	HC165L HC200	R3224-7412-P03	TAPER BEARING	4	R1-axis B/G(1)

Category	Robot Applied	PLATE No.	Product Name and Specification	Quantity	Remark
D	HC165L HC200	R3224-7412-P04	BALL BEARING	1	R1-axis MAIN BRG SHAFT
D	HC165L HC200	R3224-7412-P05	BALL BEARING	1	B-axis GEAR SHAFT
D	HC165L HC200	R3224-7412-P06	BALL BEARING	1	R1-axis (B/G) SPLINE SHAFT
D	HC165L HC200	R3224-7412-P07	BALL BEARING	2	R1-axis (B/G) SPLINE SHAFT
D	HC165L HC200	R3224-7412-P17	BALL BEARING	1	B-axis GEAR SHAFT
D	HC165L HC200	R3224-7112-P06	OIL SEAL	1	S-axis CABLE HOLLOW
D	HC165L HC200	R3224-7312-P12	OIL SEAL	1	R1-axis SPLINE SHAFT
D	HC165L HC200	R3224-7312-P13	OIL SEAL	1	B-axis SPLINE SHAFT
D	HC165L HC200	R3224-7312-P14	OIL SEAL	1	R2-axis INPUT GEAR
D	HC165L HC200	R3224-7412-P09	OIL SEAL	1	R1-axis MAIN BRG SHAFT
D	HC165L HC200	R3224-7230-P05	OIL SEAL	4	GAS SPRING JOINT
D	HC165L HC200	R3224-7112-P08	O-RING	1	S-axis CABLE HOLLOW
D	HC165L HC200	R3224-7312-P16	O-RING	1	ARM PIPE + ARM FRAME
D	HC165L HC200	R3224-7412-P10	O-RING	1	R1-axis MAIN BRG SHAFT
D	HC165L HC200	R1001-6202-P1a	LIMIT SWITCH	1	Option (S-Axis)
D	HC165L HC200	R1001-6202-P1b	LIMIT SWITCH	2	Option (H/V-Axis)

8
Decommissioning

8.1. Material for each robot part

The robot is made up of several materials as shown in [Table 8-1]. Some of them should be properly arranged and sealed up to eliminate any bad influence on the human body or environment.

Table 8-1 Materials of each part

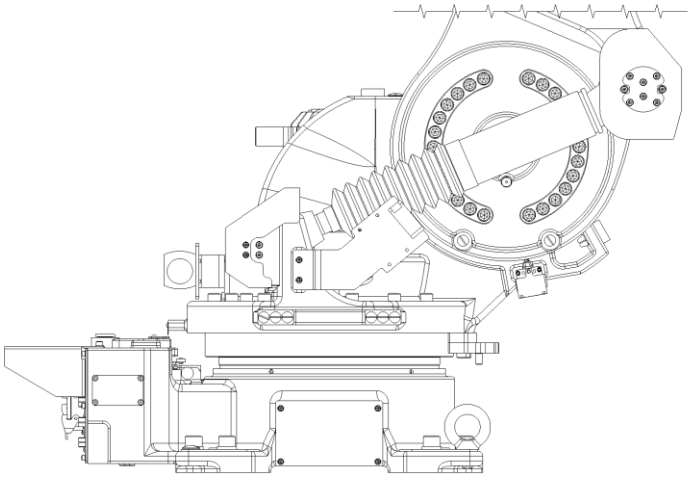
Parts	Materials
Battery	NiCad or Lithium
Wiring, Motor	Copper
Base body, Lower Frame, Upper Frame etc.	Cast Iron
Brakes, Motors	Samarium Cobalt(or Neodymium)
Wiring, Connectors	Plastic / Rubber
Reducers, Bearings	Oil / Grease
Wrist cover etc.	Aluminum alloy cast

8.2. Disposal of assembled gas spring substances

As the gas spring has been assembled under extremely high compression levels, it is very important to employ the following procedures during its disposal in order to prevent personal or property damage.

8.2.1. Dismantling the assembled gas spring substances

Before dismantling the assembled substances, please make sure the angle of the H-axis is placed as shown in [Figure 8.1]. The position minimizes the compression of the gas spring, allowing the robot to be dismantled. As a result, when separating the assembled gas spring substances from the main body, risk will be minimized during dismantling, as the spring compression is in equilibrium.
Remove gas completely according to the procedure of Release Gas from the Gas Spring, and separate it when dismantling the assembled gas spring substances to discard the gas spring or repair the interior.

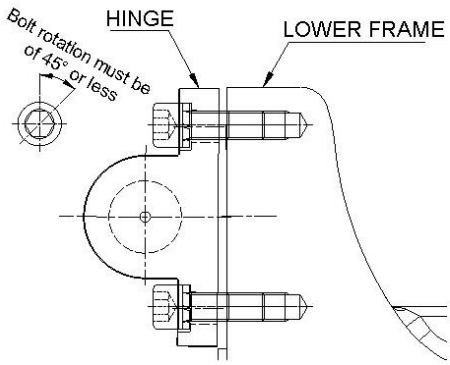


S- Axis	0
H- Axis	90
V- Axis	0
R2- Axis	0
B- Axis	0
R1- Axis	0

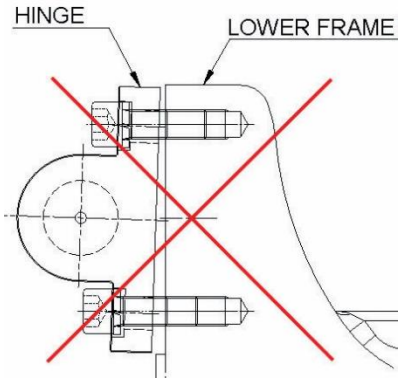
Figure 8.1 Gas spring disassembling posture

Warning

- ✓ **As shown in the picture below, fasten or loosen a bolt of the hinge by rotating a bolt on the top and the bottom alternately by 45° or less to prevent excessive tilting in the separation and assembly of assembled gas spring substances.**
- ✓ **Excessive tilting of the hinge damages a screw bolt; the damaged screw bolt damages the tap of the lower frame, which makes it hard to separate/assemble.**
- ✓ **The shape of each part, such as the hinge, is subject to change depending on a mass production design.**



[Bolt rotation of 45° or less: Approved]



[Bolt rotation of 45° or more: Not Approved]

8.2.2. Disposal of assembled gas spring substances

Remove gas completely according to the procedure of 9.3. Release Gas from the Gas Spring, and check if there is any gas left to discard the assembled gas spring substance because the interior of the assembled gas spring separated from the main body is still assembled with a high pressure. Discard the assembled gas spring substances according to the relevant regulations in the environment, which is sensitive to pollution, because some grease had been included in the gas spring.

9

Maintenance of Gas Spring

Manage the gas spring so that it has an appropriate pressure through periodic maintenance. Replace the gas spring every 20,000 hours or when the proper working pressure (125 bar–140 bar) cannot be maintained even after gas is injected.

Warning

- ✓ Nitrogen gas is filled at high pressure, so the safety regulations of the concerned country should be observed.
- ✓ To prevent the arm from falling, you should maintain the pressure of the gas spring at an appropriate working pressure.
  When required to operate the H axis manually, you must first check that the pressure of the gas spring is at an appropriate working pressure.
  Never go under in the direction of the arm falling.
- ✓ Fill only nitrogen gas.
  (Never charge other types of gas but also liquid nitrogen.)
  Must to wear safety glasses when working.
- ✓ Fill nitrogen gas so that the pressure does not drop more than 5 bar below the reference pressure.
- ✓ Never look directly into the gas inlet and pressure gauge.
- ✓ When the internal parts of the gas spring are damaged, you should secure safety by not placing any part of your body or major equipment in the operation direction of the gas spring, and then completely remove the gas.
  (When an internal part is damaged, the compression force causes it to be thrown out at high speed, resulting in a safety accident.)
- ✓ When required to separate the gas spring assembly unit, you should separate it while keeping the H axis of the robot at an angle of 90 degrees (teaching pendant). In this posture, the compression force of the gas spring is minimized, making it possible to separate it. (In other postures, the gas spring compression force is high, so the bolts will be thrown out at high speed during the separation work, resulting in a safety accident.)
- ✓ To consider safety and maintain the performance of the product, the works of disassembling and assembling the internal parts of the gas spring can be performed using only designated standard work tools and equipment with appropriate trainings and understanding of the product. Please contact us for any inquiries regarding this.
- ✓ When measuring the gas pressure, you should observe the instruction in the “Checking the Gas Spring Pressure” section because incorrect operation of the measuring device or mistakes in operating it may result in a drop in the gas pressure.
- ✓ Before checking the gas spring, you must check that the controller and external power are in『OFF』 state. Also, you should take measures to prevent the controller and external power from being turned 『ON』accidently by someone else.
- ✓ When required to replace the gas spring, you must remove the gas pressure first.
- ✓ When replacing an old gas spring, replace the bearing as well.
- ✓ Regularly inject grease into the bearing part of the gas spring.
  (every 6 months, every 3 months in severe conditions)
- ✓ When purchasing gas injection parts, you should include the specification of the nitrogen gas cylinder connection screws.

9.1. Check the Pressure of Gas Spring

(1) Set the posture of H-axis of the robot at 90° and cut the power of the controller.

(2) Remove the plug that is installed at the gas inlet of the spring.

(3) Check if the handle Bleed Valve ⓟ is locked. (Turn clockwise to lock).

(4) Check if the gas release pin, displayed as ⓡ, sticks out. If it sticks out, turn the handle ⓞ in a counterclockwise direction, careful not to stick out the pin.

(5) Match the release pin ⓡ of the pressure tester (=armature) with the center of the gas inlet, and then turn the knob ⓝ clockwise to complete the connection.

(6) Turn the knob ⓞ clockwise and stop turning when the indicator of the pressure gauge ⓣ moves.
(Do not turn the knob ⓞ excessively because it will insert the release pin ⓡ too far and cause damage to the check valve inside the spring.)
The pressure of the injected gas will be as per the following depending on the temperature at the surface of the gas spring cylinder.

(7) After the pressure is checked, turn the knob ⓞ counterclockwise to retract it, and then turn the bleed valve ⓟ counterclockwise to release residual gas in the pressure tester.

(8) Turn the base handle ⓝ of the pressure tester in a counterclockwise direction to separate it, and install the plug again.

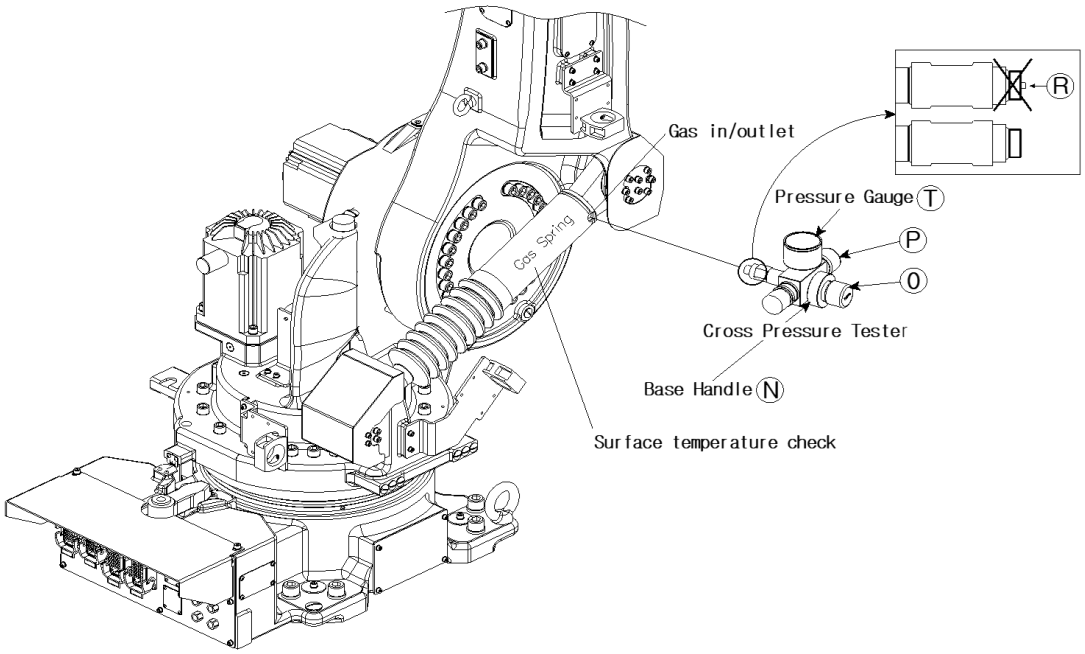


Figure 9.1 Check the Pressure of the Gas Spring

Table 9-1 Pressure Table by Gas Spring Surface Temperature- Set gas pressure

Temperature (℃)	0	5	10	15	20	25	30	35	40	45
Pressure (bar)	126	128	130	133	135	137	140	142	144	147

Each time the gas pressure is measured, the pressure will decrease by about 0.5 bars.
The name and the position of the cross pressure tester (Pressure tester = armature) may vary depending on the type.

9.2. Charge Gas into the Gas Spring

Warning

- ✓ **Follow the safety regulations of the corresponding countries because nitrogen gas charging is high pressure.**
- ✓ **Charge nitrogen gas only.**
  (Do not charge gasses other than nitrogen and liquid nitrogen.)
- ✓ **Wear safety glasses during work.**
- ✓ **Do not look into the gas inlet and pressure gauge directly.**
- ✓ **Make sure to refill or charge gas while the gas spring is assembled in the robot.**
- ✓ **After charging gas, wait for 30 minutes until the temperature comes back to room temperature, and then use it.**
- ✓ **Before checking the gas spring, make sure that the controller and the external power are turned "OFF." In addition, take precautions so that any other person cannot turn the controller or the external power "ON" accidentally.**

9.2.1. When the pressure of the nitrogen gas container exceeds 150bar

(1) Set the posture of the H-axis of the robot at 90° and cut the power of the controller.

(2) Remove the plug that is installed at the gas inlet of the spring and connect the charging plug.

(3) Check the closed state of the bleed valve ⓟ and shutoff valve ⓠ of the pressure tester. (Turn clockwise to close)

(4) Turn the knob ⓞ in a counterclockwise direction, careful not to stick out the release pin ⓡ.

(5) Turn the knob ⓝ of the pressure tester clockwise to completely connect it to the gas inlet.

(6) Check whether handle ⓤ and the shutoff valve ⓠ are locked.

(7) Connect the connection section screw of the regulator to the nitrogen gas container screw. (Connect the hoses as shown in the figure.)
Because the specification for the nitrogen gas container screw varies in different countries, you must purchase a regulator that fits the specification of the nitrogen gas container screw.
If the pressure of the nitrogen gas container is below 150bar, both a regulator and a booster should be mounted. (Conditions for nitrogen gas containers that can be filled up without a booster. : the capacity has to fill the pressure of 150 bars or more and the gas spring pressure of 140 bars.)

(8) Gauge ⓧ shows the set gas pressure and gauge ⓨ indicates the pressure of the nitrogen gas container.

(9) Open the knob ⓩ of the nitrogen gas container, and turn the handle ⓤ of the regulator (ⓥ) to set the gas pressure. (The set gas pressure is specified in Table 9.1 Pressure per temperature.)

(10) Open the shutoff valve ⓠ slowly and charge until the pressure gauge ⓣ reaches the set pressure.

(11) If the set pressure is reached, lock valve ⓠ and then open the bleed valve ⓟ to release the residual pressure inside the pressure tester.
Do not turn the bleed valve ⓟ by more than 360 ˚ .

(12) Close the bleed valve ⓟ to adjust the pressure of the gas spring.

(13) Check the pressure of the pressure gauge Ⓣ while turning the knob ⓞ slowly in a clockwise direction.
Be careful not to damage the valve installed in the gas string with the release pin Ⓡ.

(14) When the set pressure is exceeded, repeatedly open and close the bleed valve ⓟ slightly to adjust the gas pressure to the desired level.

(15) Turn the knob ⓞ counterclockwise to retract the release pin ⓡ.

(16) If the pressure has been checked, open the bleed valve ⓟ to completely release the residual pressure inside the pressure tester.

(17) Lock the knob Ⓩ of the nitrogen gas container and loosen the connection section of the regulator to separate it from the nitrogen gas container.

(18) Separate the shutoff connection section from the pressure tester.

(19) Turn the knob Ⓝ of the pressure tester in a counterclockwise direction to separate it from the gas spring.

(20) Check if there is oil or air leakage in the check valve of the gas spring.
Warning! Do not look into the check valve hole directly while gas is charged in the gas cylinder.

(21) Install the G1/8 plug to the gas spring.
After charging gas, wait for 30 minutes until the temperature comes back to room temperature, and then use it.

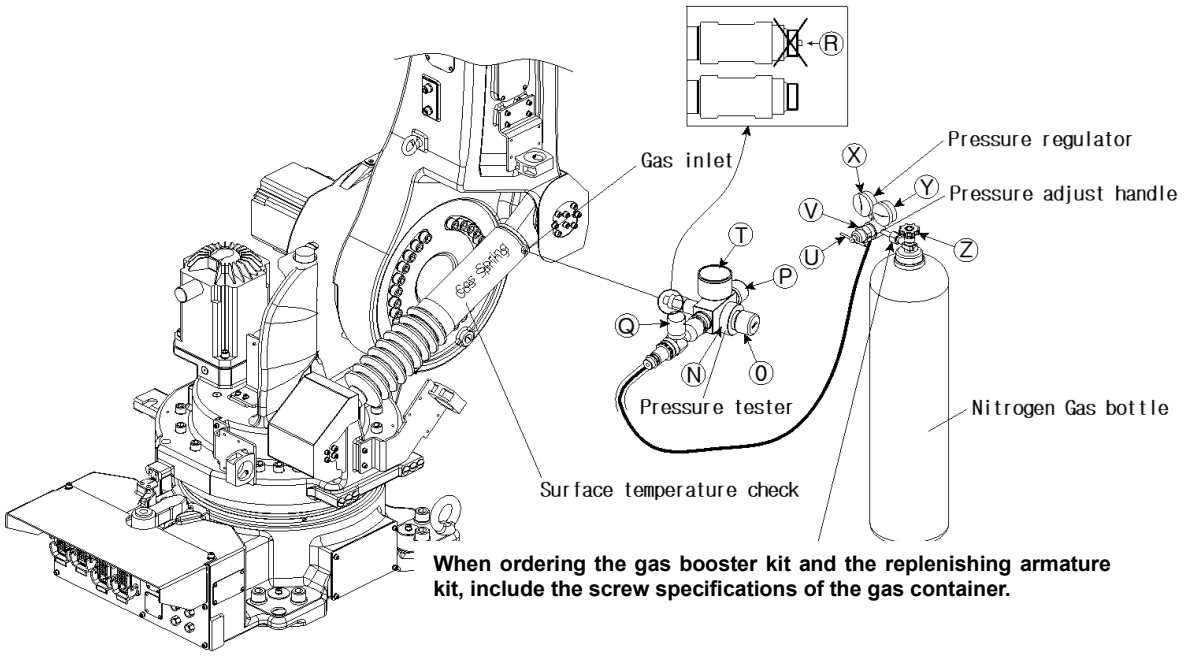


Figure 9.2 Charge Gas into the Gas Spring

As the shape and name of the gas supplement kit may vary depending on the type, refer to the accompanying manual.

9.2.2. When the pressure of the nitrogen gas container goes below 150bar (Supplement the gas by using a booster)

(1) Position the H axis of the robot at 90 degrees and cut off the power of the controller.

(2) Remove the plug installed in the gas inlet of the spring.

(3) Check the closed state of the bleed valve ⓟ and shutoff valve ⓠ of the pressure tester. (Turn clockwise to close)

(4) Turn the knob ⓞ counterclockwise to prevent the release pin ⓡ from protruding.

(5) Turn the knob ⓝ of the pressure tester clockwise to completely connect it to the gas inlet.

(6) Check whether the handle ⓤ, shutoff valve ⓦ, knob ⓢ (Knob of the air hose owned by the customer) and the shutoff valve ⓠ are locked.

(7) Connect the connection section screw of the regulator to the nitrogen gas container screw. (Connect the connection section of the hoses to individual connection inlets.)
Because the specification for the nitrogen gas container screw varies in different countries, you must purchase a regulator that fits the specification of the nitrogen gas container screw.

(8) Gauge ⓧ shows the set gas pressure and gauge ⓨ indicates the pressure of the nitrogen gas container.

(9) Open the knob ⓩ of the nitrogen gas container, and turn the handle ⓤ of the regulator ⓥ to set the gas pressure. (The set gas pressure is specified in Table 9.1 Pressure per temperature.)

(10) Open the shutoff valve ⓦ of the hose connected to the regulator ⓥ and slowly turn the shutoff valve ⓠ, which is to be connected to the pressure tester, counterclockwise until the indicator of the pressure gauge ⓣ matches with the indicator of the gauge ⓧ.

(11) When the knob ⓢ (Knob of the air hose owned by the customer) is opened after the connection section of the air hose is connected to the booster, the booster starts operation.
Charge until the indicator of the pressure gauge ⓣ reaches the set pressure.
While charging is in progress, the minimum air pressure should be above 5bar. When the residual pressure of the nitrogen gas container goes below 30bar, carry out replacement.

(12) If the set pressure is reached, lock the valve ⓠ and open the bleed valve ⓟ to release the residual pressure inside the pressure tester.
(Do not turn the bleed valve ⓟ by more than 360 ˚ .)

(13) Lock the bleed valve ⓟ and slowly turn the knob ⓞ clockwise while checking whether the indicator of the pressure gauge ⓣ matches with the set pressure before stopping.
Be careful not to cause damage to the check value mounted to the gas spring by inserting the release pin ⓡ too far.

(14) When the set pressure is exceeded, repeatedly open and close the bleed valve ⓟ slightly to adjust the gas pressure to the desired level.

(15) Turn the knob ⓞ counterclockwise to retract the release pin ⓡ.

(16) If the pressure is checked, open the bleed valve ⓟ to completely release the residual pressure inside the pressure tester.

(17) Lock the knob ⓢ of the air hose and separate it from the booster.

(18) Lock the shutoff valve ⓦ of the hose connected to the regulator and then lock the handle ⓤ.

(19) Close the knob ⓩ of the nitrogen gas container and separate the hose connected to the regulator from the booster, and then open the shutoff valve to completely release the residual pressure inside.

(20) Separate the shutoff connection section from the pressure tester.

(21) Turn the knob ⓝ of the pressure tester counterclockwise to separate it from the gas spring. Install the G1/8 plug to the gas spring.
After charging gas, wait for 30 minutes until the temperature comes back to room temperature, and then use it.

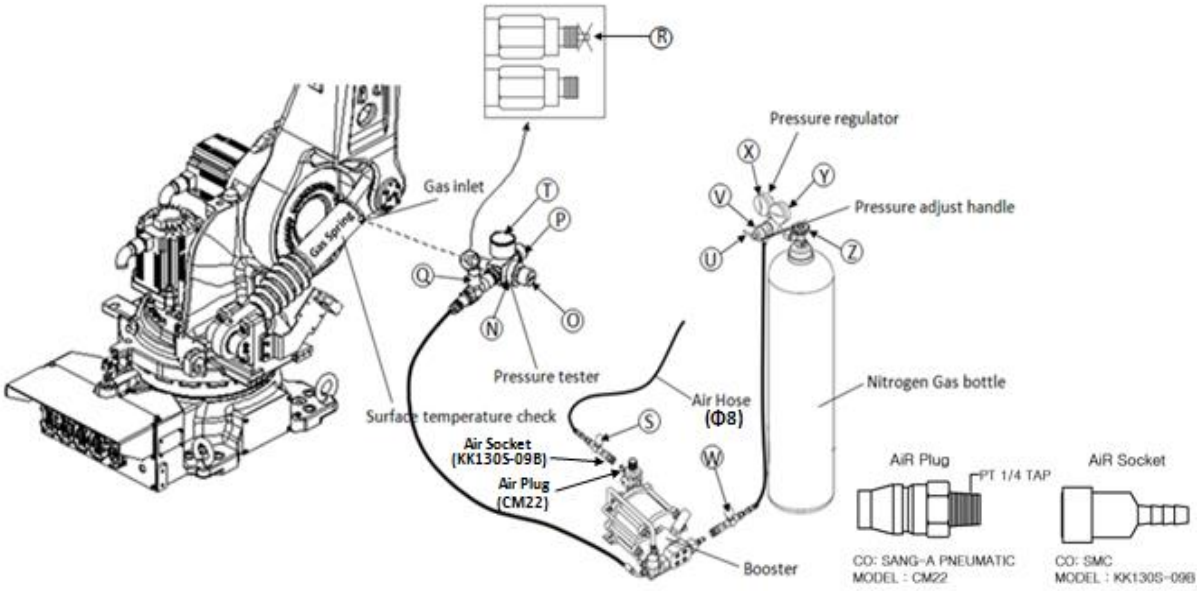


Figure 9.3 Refill the gas into the gas spring of booster

As the shape and name of the gas supplement kit may vary depending on the type, refer to the accompanying manual.
To refill or charge using the booster, refer to the manual provided with the kit.

9.3. Release Gas from the Gas Spring

Releasing of gas from the gas spring will be performed in each of the following cases:

- In the event that the H-axis cannot be placed at 90°because of its nonoperation when you want to remove the gas spring from the robot
- In the event the robot is to be transported by air. (The law mandates that transportation of machinery to which high-pressure equipment is attached should be made after removing its pressure.)

Cautions

When the gas is released rapidly, the colored oil inside the spring may gush out. Wear safety glasses and ensure that discharging takes place slowly.

(1) Remove the plug that is installed at the gas inlet of the spring.

(2) Check if the handle Bleed Valve ⓟ is locked (turn clockwise to lock).

(3) Check if the gas release pin, displayed as ⓡ, sticks out. If the release pin is protruding, turn the knob ⓞ counterclockwise to prevent it from protruding.

(4) Turn the base handle ⓝ of the pressure tester in a clockwise direction to connect it to the gas inlet.

(5) Turn the knob ⓞ clockwise and stop turning when the indicator of the pressure gauge ⓣ moves. (Do not turn the handle ⓞ excessively to prevent damage to the valve in the gas spring from the release pin ⓡ.)

(6) Turn the gas discharge handle Bleed Valve ⓟ slowly in a counterclockwise direction to discharge gas completely.
Warning! Do not look into the gas inlet hole directly.

(7) Turn the knob ⓞ counterclockwise to retract the release pin ⓡ, and then turn the knob ⓝ of the pressure tester counterclockwise to separate it.

(8) Install the G1/8 plug to the gas spring.

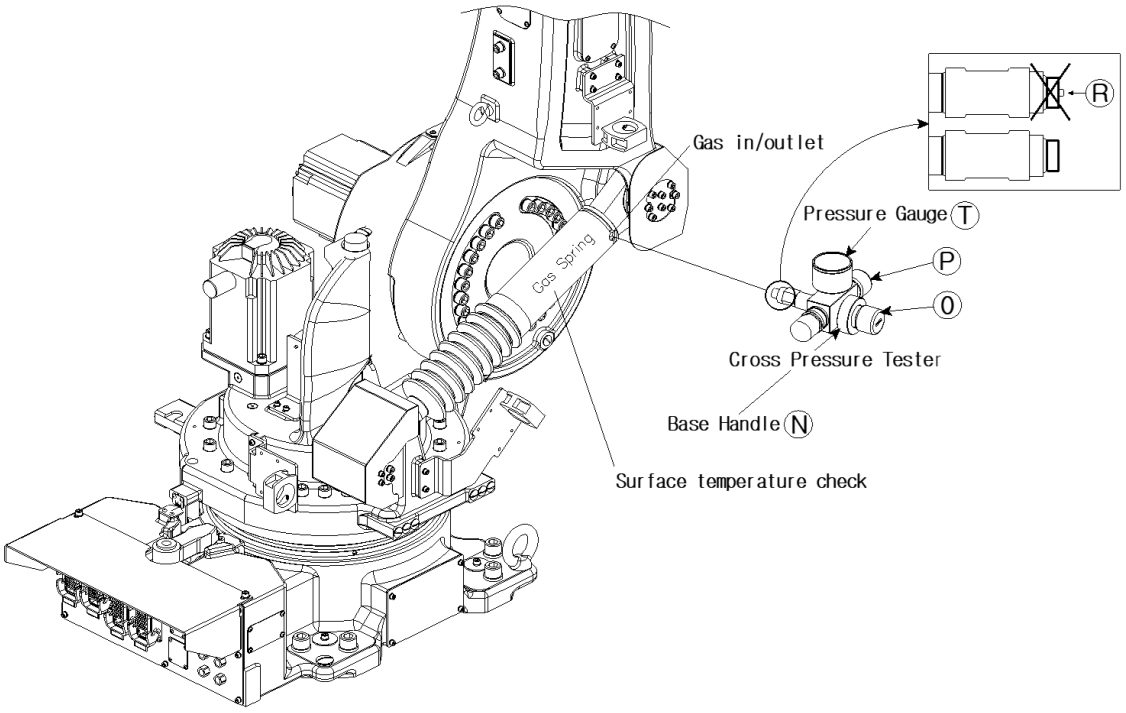


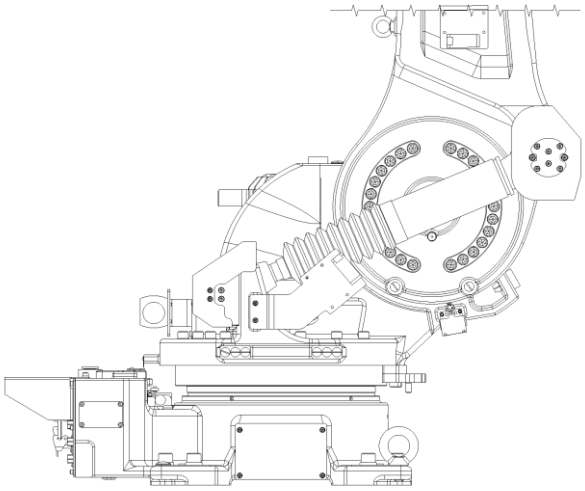
Figure 9.4 Release Gas from the Gas Spring

9.4. Replace Assembled Gas Spring Substances (Separation and assembling)

Replace the assembled gas spring substances together with the bearing assembled in the BS JOINT.

9.4.1. Separate Assembled Gas Spring Substances

The H-axis angle must be assembled in the position as shown in [Figure 9.5] to assemble assembled gas spring substances. Assembly is available at this position because a compressive force of the gas spring had been minimized in the position. So the risk factor is minimized during the disassembly process because the compressive force is equilibrated by the spring even if the gas spring assembly is removed from the main body
However, while carrying out separation to dispose of the gas spring or to do internal repair work, if it is impossible to place the H axis at 90° because the H axis does not work, remove the gas completely by following 9.3 Gas Release Procedure

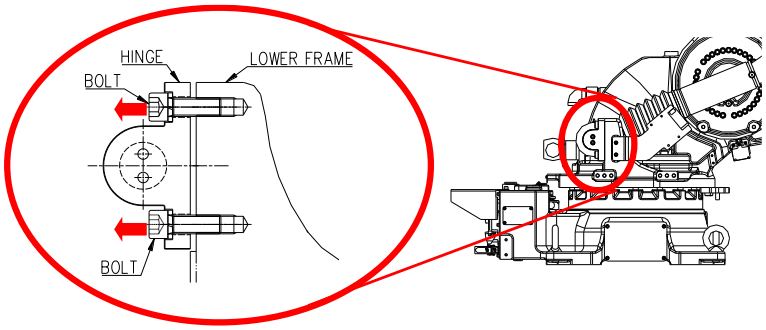


H- Axis	90 °

Figure 9.5 Gas spring disassembling posture

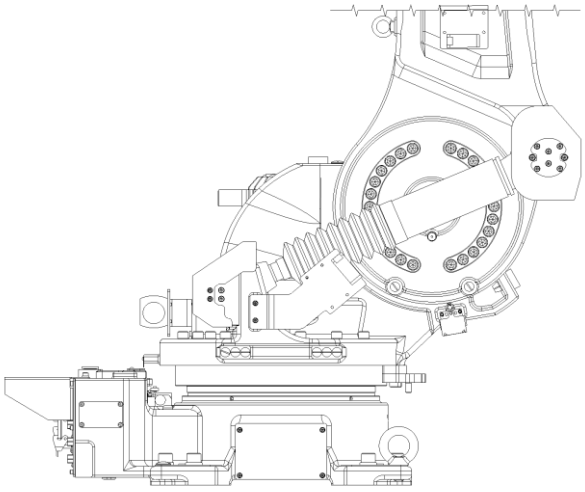
Warning

✓ **Posture that must not be allowed in separating the assembly unit of the gas spring: H axis at degrees other than 90˚**
(In other postures than H axis at 90˚, the compression pressure of the gas spring will be excessive, meaning that the screw thread will get damaged and the bolts will be ejected at high speed because of the pressure of the gas spring when loosening the bolts of the hinge, causing accidents involving people and damages to equipment.)



9.4.2. Assemble Assembled Gas Spring Substances

The H-axis angle must be assembled in the position as shown in [Figure 9.6] to assemble assembled gas spring substances. Assembly is available at this position because a compressive force of the balance spring had been minimized in the position

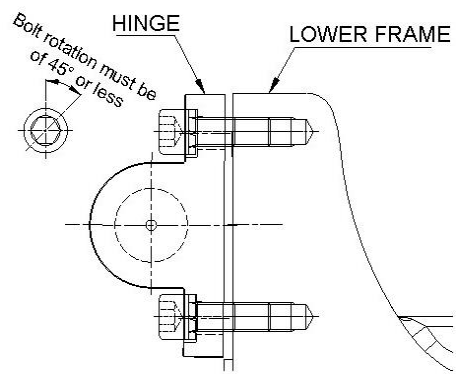


S- Axis	0
H- Axis	90
V- Axis	0
R2- Axis	0
B- Axis	0
R1- Axis	0

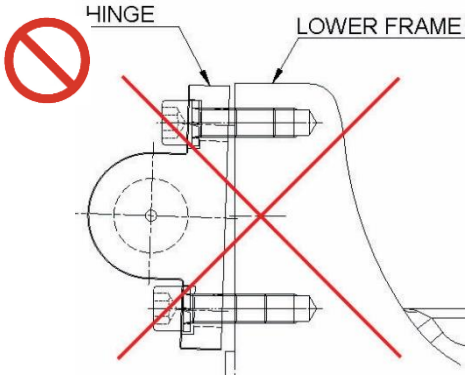
Figure 9.6 Gas Spring Assembly Position

Warning

- ✓ **When fastening and loosening the bolts of the hinge of the assembly unit of the gas spring, work at the bolts at the top and bottom and at the left and right in an alternating manner and turn the bolt 45 degrees/each time to prevent the hinge from tilting excessively.**
- ✓ **Excessive tilting of the hinge damages a screw bolt; the damaged screw bolt damages the tap of the lower frame, thereby making it hard to separate/assemble.**
- ✓ **The shape of each part, such as the hinge, is subject to change depending on a mass production design.**



[When fastening the bolts by turning less than 45 degrees: No damage to the screw]



[Bolt rotation of 45° or more: Damage to the screw]

Figure 9.7 Cautions on Fastening and Loosening the Gas Spring Hinge

9.4.3. Gas Spring Technology Data

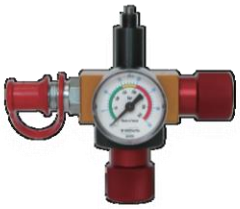
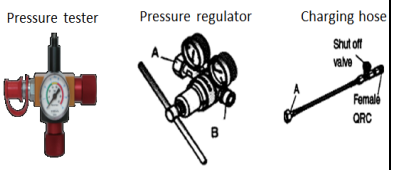
Table 9-2 Gas Spring Technology Data

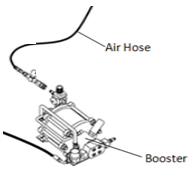
Division	DATA		Remark
	HC165L	HC200	
Pressure Medium	Nitrogen gas / Hydraulic oil		
Length of Stroke	200mm		
Operation Temperature	0 ℃ ~ 80 ℃		
Gas Volume	0.9 liter		
Maximum Charging Pressure	140 bar		When the spring surface is 30℃
Appropriate working pressure	140 bar ~ 125 bar		Maintenance Target Pressure When the spring surface is 30℃
Minimum Allowable Pressure	105 bar		When the spring surface is 30℃
Weight	About 16 kg		

※ Refer to Table 9-1 Pressure Table by Gas Spring Surface Temperature for the pressure
※ The minimum allowable pressure can vary depending on the load of the robot motor

9.4.4. Parts for the gas spring pressure measurement and gas charging

Table 9-3 Parts for the gas spring pressure measurement and gas charging

Product name and specification	PLATE No.	Quantity	Shape	Supplied items
GAS SPRING & BS JOINT & BELLOWS(1) & Nipple	R3224-7230-001(1)	1		Hyundai Robotics (Option)
Bearing Collar	R3224-7230-218	2		
Spherical Bearing 22208	R3224-7230-P02	2		
Nilos Ring 22208JV	R3224-7230-P03	4		
PRESSURE TESTER-1 (FOR PRESSURE MEASUREMENT)	R3224-7230-R01	1		Hyundai Robotics (Option)
REPLENISHING ARMATURE KIT-1 + GAS BOOSTER KIT-1 1. For charging gas when the nitrogen gas container pressure is below 150bar 2. Items to be included when the customer places an order: Specification of the connection section screw for the nitrogen gas container	R3224-7230-R05 + R3224-7230-R03	1		Hyundai Robotics (Option)
REPLENISHING ARMATURE KIT-1 1. For charging gas when the nitrogen gas container pressure exceeds 150bar 2. Items to be included when the customer places an order: Specification of the connection section screw for the nitrogen gas container	R3224-7230-R05	1		Hyundai Robotics (Option)
GAS BOOSTER KIT-1 1. For boosting the pressure when the nitrogen gas container pressure is below 150bar 2. AIR INLET PLUG MALE : R1/4 3. Items to be included when the customer places an order: Specification of the connection section screw for the nitrogen gas container	R3224-7230-R03	1		Hyundai Robotics (Option)

Air hose & quick coupling (to supply the air)	-	1		Customer

10
Internal Wiring Diagram

Internal wiring is shown in a connection diagram per unit, and thus utilizes it to inspect and replace the wiring.

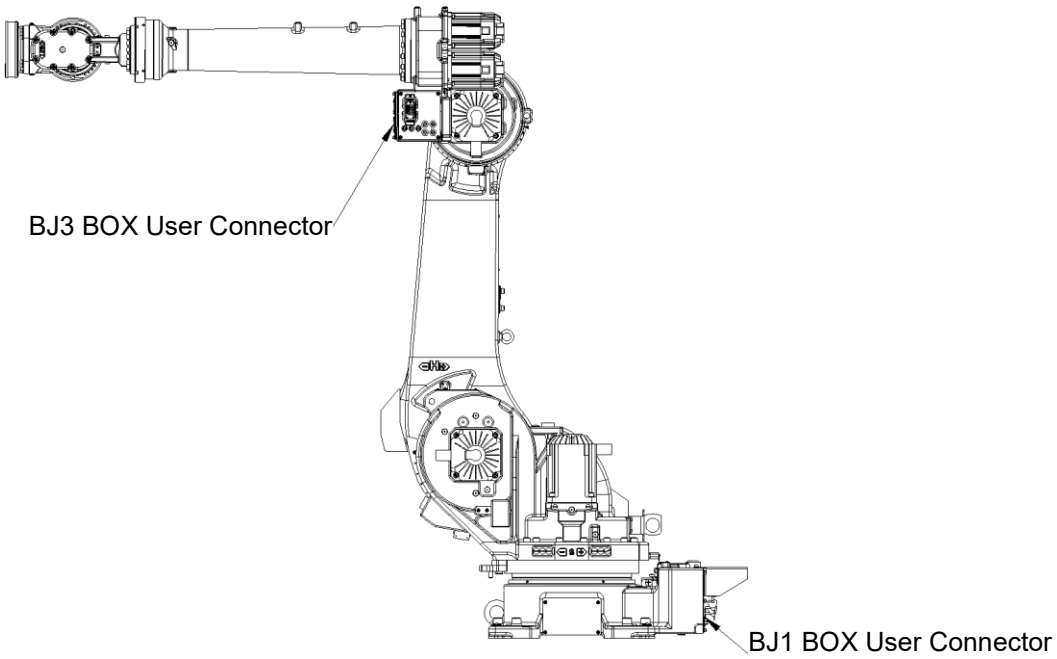
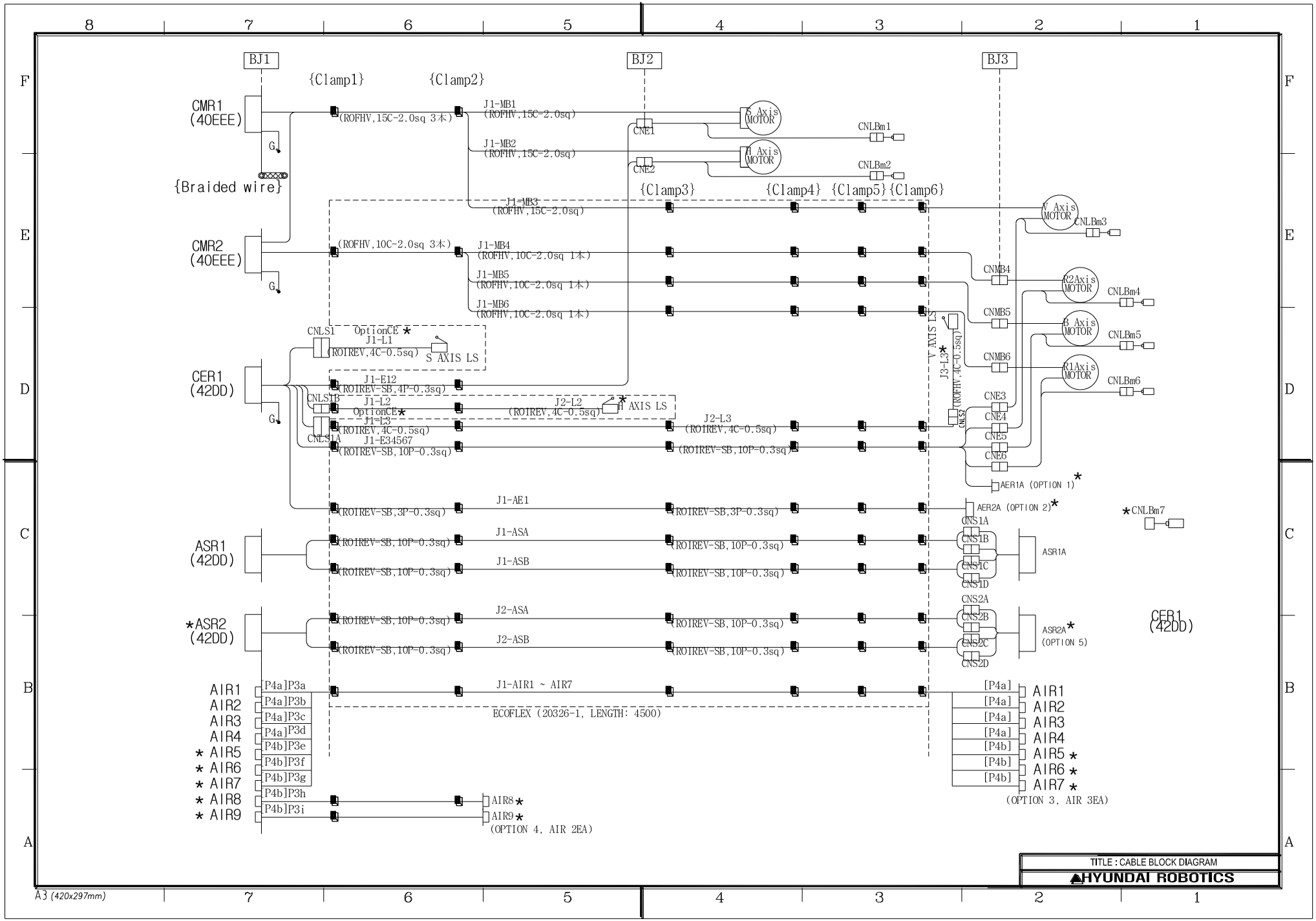


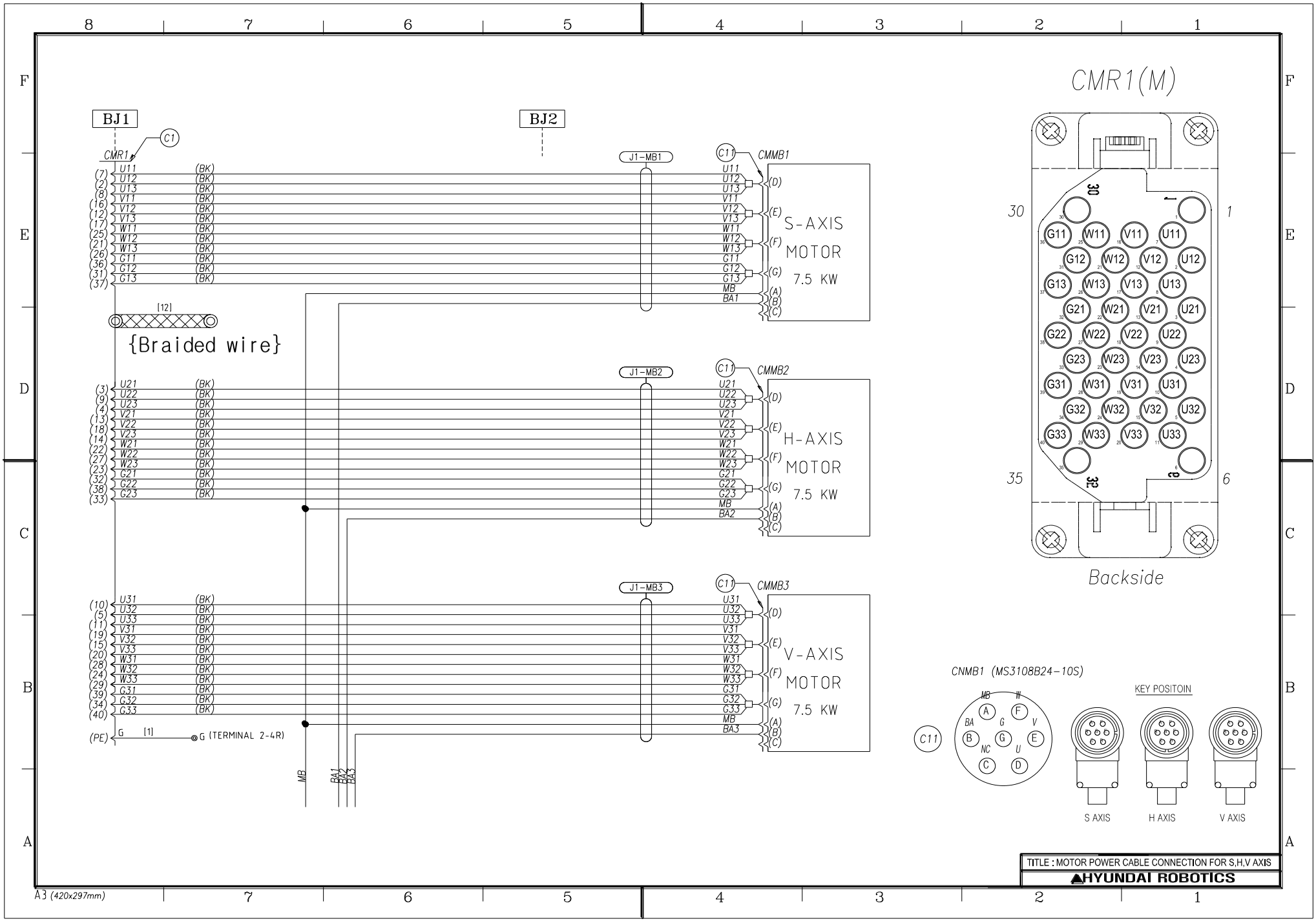
Figure 10.1 Manipulator Configuration

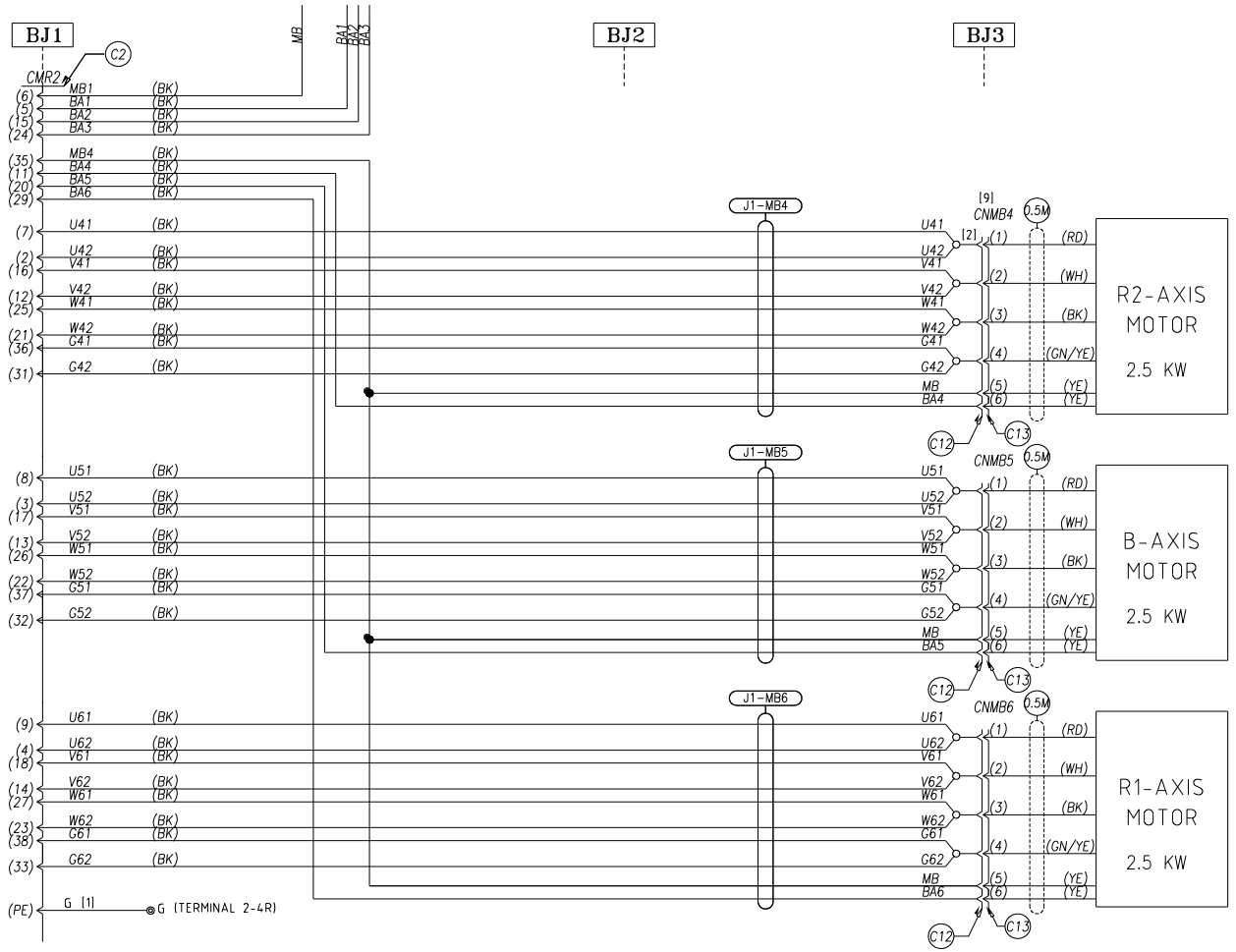
HC165L / HC200 Internal wiring diagram

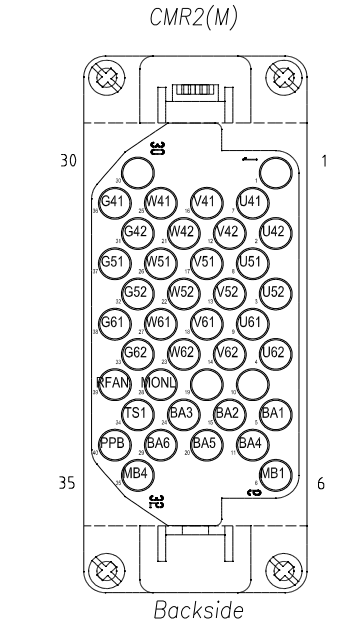
HYUNDAI ROBOTICS

A3 (420x297mm)


BJ1
BJ2
BJ3
{Clamp1}
{Clamp2}
{Clamp3}
{Clamp4}
{Clamp5}
{Clamp6}
CMR1 (40EEE)
CMR2 (40EEE)
{Braided wire}
(ROFHV,15C-2.0sq 3本)
J1-MB1 (ROFHV,15C-2.0sq)
J1-MB2 (ROFHV,15C-2.0sq)
J1-MB3 (ROFHV,15C-2.0sq)
(ROFHV,10C-2.0sq 3本)
J1-MB4 (ROFHV,10C-2.0sq 1本)
J1-MB5 (ROFHV,10C-2.0sq 1本)
J1-MB6 (ROFHV,10C-2.0sq 1本)
S Axis MOTOR
L Axis MOTOR
U Axis MOTOR
R2Axis MOTOR
B Axis MOTOR
R1Axis MOTOR
CNE1
CNE2
CNLBm1
CNLBm2
CNLBm3
CNLBm4
CNLBm5
CNLBm6
CNMB4
CNMB5
CNMB6
CNE3
CNE4
CNE5
CNE6
CNLS1
OptionCE *
J1-L1
(ROIREV,4C-0.5sq)
S AXIS LS
CER1 (42DD)
J1-E12
(ROIREV-SB,4P-0.3sq)
CNLS1B
J1-L2
OptionCE*
J2-L2
(ROIREV,4C-0.5sq)
L AXIS LS
CNLS1A
J1-L3
(ROIREV,4C-0.5sq)
J2-L3
(ROIREV,4C-0.5sq)
J1-E34567
(ROIREV-SB,10P-0.3sq)
(ROIREV-SB,10P-0.3sq)
U AXIS LS
J3-L3*
CNLS2
(ROFHV,4C-0.5sq)
AER1A (OPTION 1)*
AER2A (OPTION 2)*
*CNLBm7
(ROIREV-SB,3P-0.3sq)
J1-AE1
ASR1 (42DD)
J1-ASA
J1-ASB
(ROIREV-SB,10P-0.3sq)
CNS1A
CNS1B
CNS1C
CNS1D
ASR1A
*ASR2 (42DD)
J2-ASA
J2-ASB
CNS2A
CNS2B
CNS2C
CNS2D
ASR2A*
(OPTION 5)
CER1 (42DD)
AIR1
AIR2
AIR3
AIR4
* AIR5
* AIR6
* AIR7
* AIR8
* AIR9
[P4a]P3a
[P4a]P3b
[P4a]P3c
[P4a]P3d
[P4b]P3e
[P4b]P3f
[P4b]P3g
[P4b]P3h
[P4b]P3i
J1-AIR1 ~ AIR7
ECOFLEX (20326-1, LENGTH: 4500)
AIR8*
AIR9*
(OPTION 4, AIR 2EA)
[P4a]
[P4b]
AIR1
AIR2
AIR3
AIR4
AIR5 *
AIR6 *
AIR7 *
(OPTION 3, AIR 3EA)
TITLE : CABLE BLOCK DIAGRAM
HYUNDAI ROBOTICS
A3 (420x297mm)


BJ1
BJ2
C1
CMR1
J1-MB1
C11
CMMB1
S-AXIS
MOTOR
7.5 KW
[12]
{Braided wire}
J1-MB2
CMMB2
H-AXIS
MOTOR
7.5 KW
J1-MB3
CMMB3
V-AXIS
MOTOR
7.5 KW
(PE)
G
[1]
G (TERMINAL 2-4R)
MB
BA1
BA2
BA3
CMR1(M)
Backside
CNMB1 (MS3108B24-10S)
KEY POSITOIN
S AXIS
H AXIS
V AXIS
TITLE : MOTOR POWER CABLE CONNECTION FOR S,H,V AXIS
HYUNDAI ROBOTICS
A3 (420x297mm)



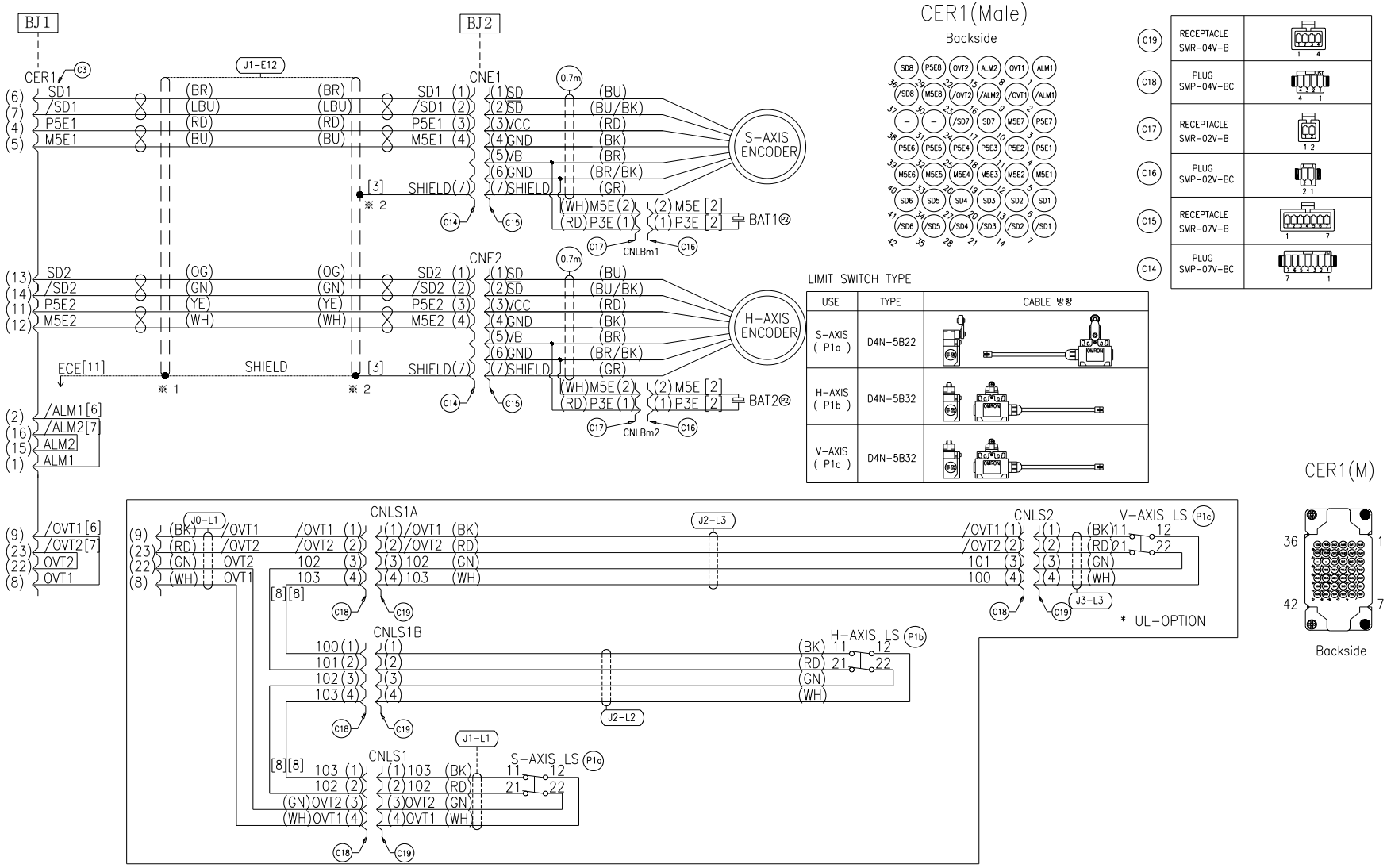


C13	RECEPTACLE VLR-06V (JST)	3 2 1 / 6 5 4
C12	PLUG VLP-06V (JST)	6 5 4 / 3 2 1

TITLE : MOTOR POWER CABLE CONNECTION FOR R2,B,R1 AXIS

HYUNDAI ROBOTICS

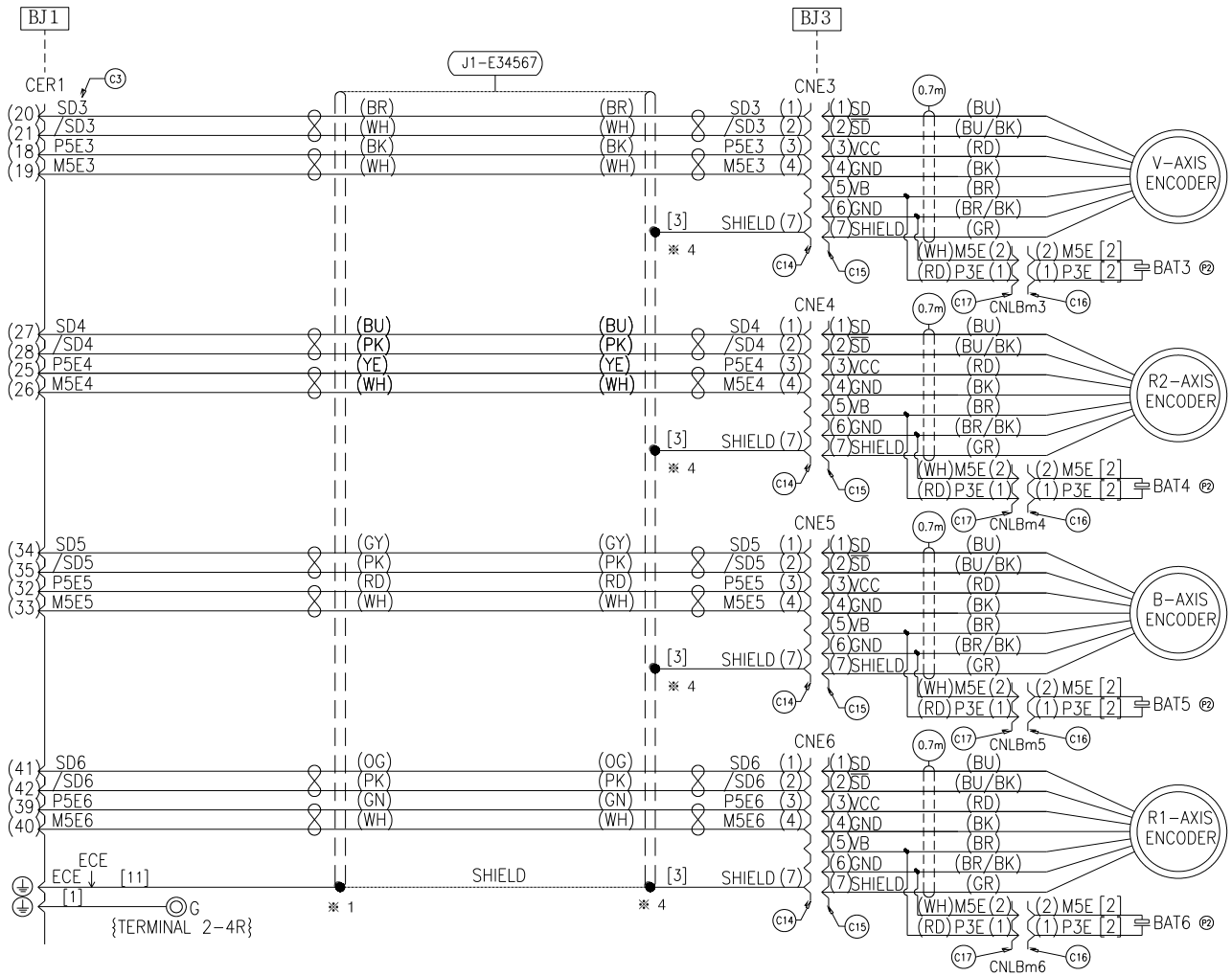
A3 (420x297mm)



TITLE : MOTOR ENCODER CABLE CONNECTION FOR S,H AXIS

HYUNDAI ROBOTICS

A3 (420x297mm)



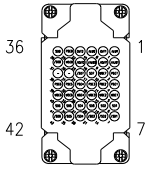
C17	RECEPTACLE SMR-02V-B	1 2
C16	PLUG SMP-02V-BC	2 1
C15	RECEPTACLE SMR-07V-B	1 7
C14	PLUG SMP-07V-BC	7 1

CER1(Male)

Backside

	SD8	P5E8	OVT2	ALM2	OVT1	ALM1
36	/SD8	M5E8	/OVT2	/ALM2	/OVT1	/ALM1
37	–	–	/SD7	SD7	M5E7	P5E7
38	P5E6	P5E5	P5E4	P5E3	P5E2	P5E1
39	M5E6	M5E5	M5E4	M5E3	M5E2	M5E1
40	SD6	SD5	SD4	SD3	SD2	SD1
41	/SD6	/SD5	/SD4	/SD3	/SD2	/SD1
42	35	28	21	14	7	

CER1(M)



Backside

TITLE : MOTOR ENCODER CABLE CONNECTION FOR V,R2,B,R1 AXIS

HYUNDAI ROBOTICS

A3 (420x297mm)

BJ1

BJ1 — * OPTION 1 (ROBOT SERVO GUN ENCODER) — BJ3

CER1 (C3) — J1-E34567 — AER1A (C6)

(17)	SD7	(LBU)		(LBU)	SD7	(2)
(24)	/SD7	(PK)		(PK)	/SD7	(3)
(3)	P5E7	(PP)		(PP)	P5E7	(4)
(10)	M5E7	(PK)		(PK)	M5E7	(5)
⏚	ECE		※ 1	[10]	SHIELD	(8)

※ 4

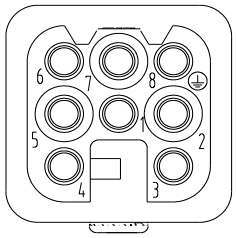
* OPTION 2 (ROBOT SERVO GUN ENCODER DUAL)

CER1 (C3) — J1-AE1 — AER2A (C7)

(36)	SD8	(BK)		(BK)	SD8	(2)
(37)	/SD8	(WH)		(WH)	/SD8	(3)
(29)	P5E8	(RD)		(RD)	P5E8	(4)
(30)	M5E8	(BK)		(BK)	M5E8	(5)
G	[5] Terminal 5-4R		※ 1	[4]	SHIELD	(8)

※ 4

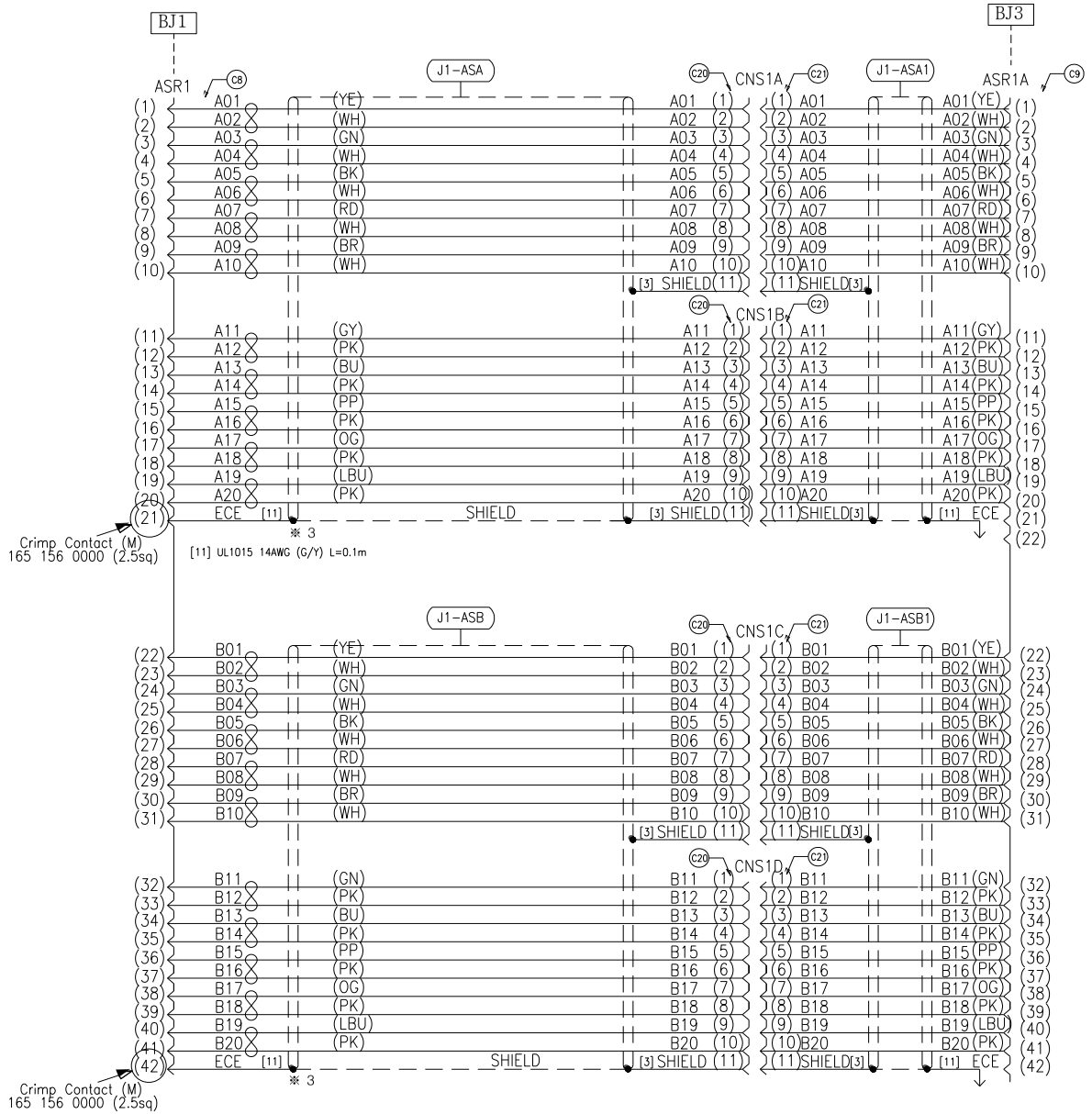
AER1A(F)
AER2A(F)



TITLE : SERVO GUN POWER CONNECTION

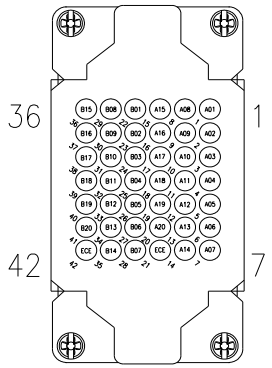
HYUNDAI ROBOTICS

A3 (420x297mm)



BJ1

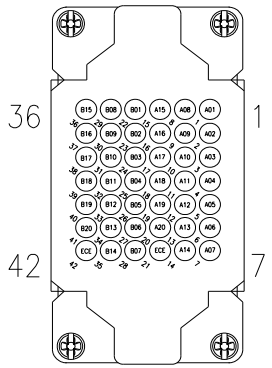
ASR1(M)



Backside

BJ3

ASR1A(F)



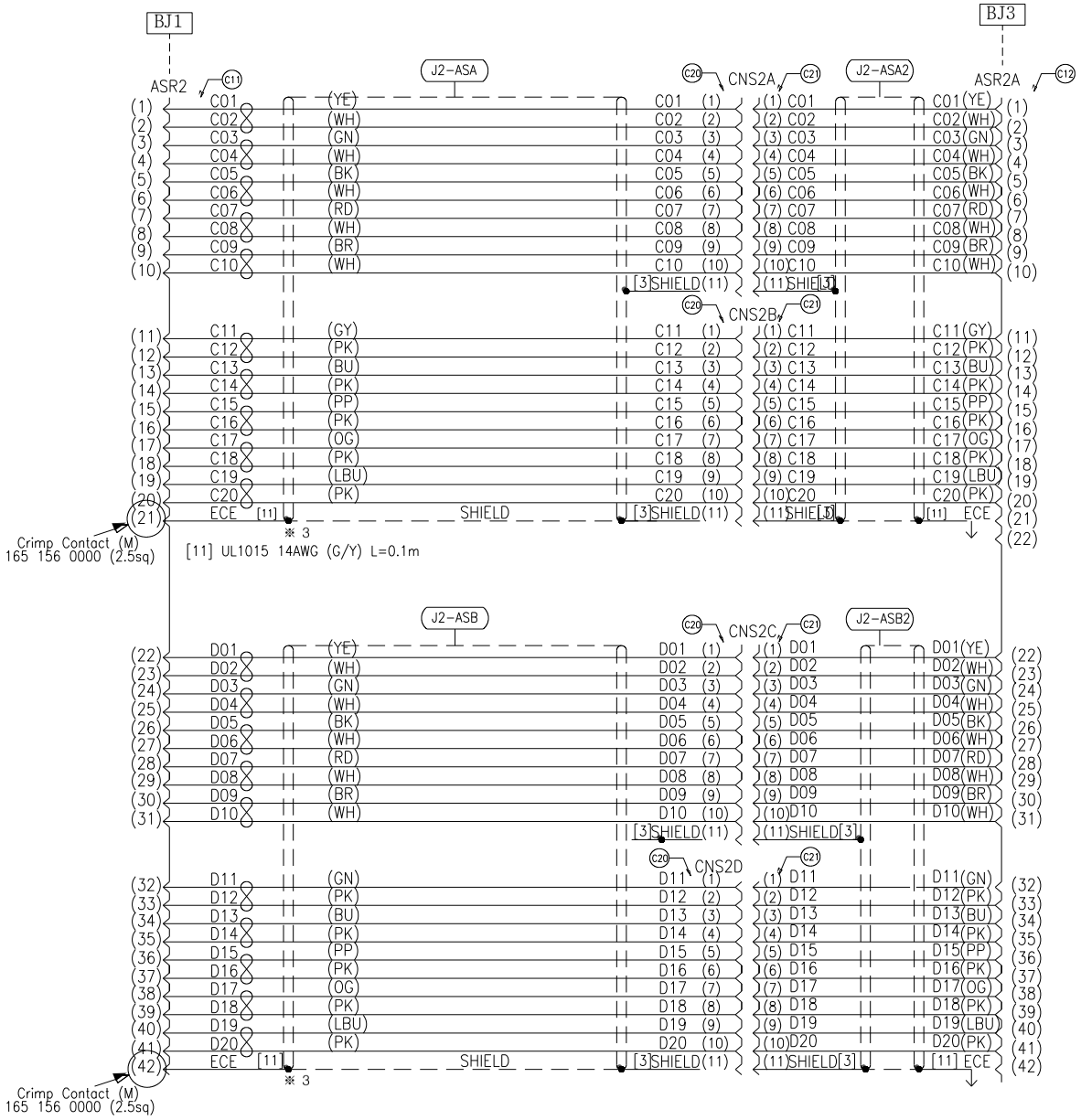
Frontside

TITLE : USER APPLICATION CONNECTION

HYUNDAI ROBOTICS

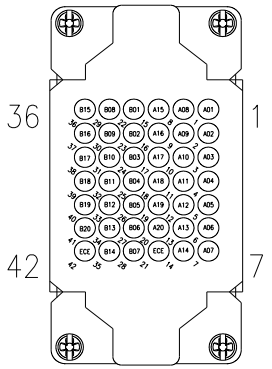
A3 (420x297mm)

* OPTION 5



BJ1

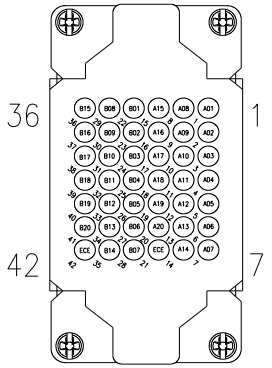
ASR2(M)



Backside

BJ3

ASR2A(F)



Frontside

TITLE : USER I/O CONNECTION

HYUNDAI ROBOTICS

A3 (420x297mm)