HD HYUNDAI ROBOTICS

Warning

All installation work must be performed by a qualified installer and must comply with applicable laws and regulations.

HD
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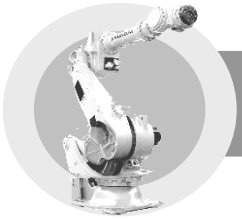
Hyundai Robot

HS220230414MMEN18



Manipulator Maintenance Manual

HS180 / HS220 / HS160L

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HYUNDAI ROBOTICS

1 Safety

1.1. Introduction

The main purpose of this chapter is to describe the matters concerning the safety of the users of the industrial robot and the workers who maintain and operate it.

This manual complies with the safety regulations of UC Machinery Directive 98/37/EC (2006/42/EC) and USA OSHA and describes the matters concerning the safety of the manipulator and controller. The manipulator and controller are manufactured in compliance with the safety standards EN ISO 10218-1:2006 and ANSI/RIA R15.06-1999.

Every worker who installs, replaces, adjusts, operates, preserves, and maintains the robot system, must thoroughly read, and fully understand the operation and maintenance manuals. In particular, it is required to pay special attention to the ⚠ symbol, the most important warning mark related to safety.

Installation, replacement, adjustment, operation, preservation, and maintenance of the robot system should be performed by those who are trained for these purposes, following the instructed work procedures.

As our company plans and performs trainings on preservation, maintenance, and operation for those works, the robot users should ensure that those working on the robot receive the relevant trainings. In addition, it must be ensured that only the workers who have completed this training courses can handle the robot.

The users of our industrial robot are responsible not only for clearly understanding and complying with safety-related laws related to robots applied in their countries, but also for properly designing, installing, and operating safety systems to protect workers working in our robot systems.

In dangerous areas, where the robot, tools, and peripheral systems are operating, safety devices should be prepared in accordance with ANSI/RIA R15.06-1999 to prevent objects other than workers and workpieces from entering those dangerous areas of the robot system. The systems should be configured so that the robot system can be immediately stopped by an emergency stop system in case a worker or object should enter the dangerous areas despite danger. The workers are responsible for installing, checking, and operating those safety systems.

1.1.1. Cautions

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

(1) 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.
(2) 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.
(3) 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.
(4) 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.
(5) If grease 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 applicable areas of the robot, and the environments where it cannot be used are as follows.

Applicable areas

The applicable areas include the industrial robots that are used by being installed on a flat surface (an axis can be added.) In addition, the work of controlling in a point section or continuous section would be proper.

Main applicable areas are as follows.

- Spot welding
- Arc welding
- Cutting
- Handling
- Assembling
- Sealing
- Palletizing
- Grinding

To use the robot for purposes other than the main application areas mentioned above, the use and applicability of the robot should be considered. Therefore, please be sure to contact us.

Unusable environments

The robot cannot be used in highly explosive environments and areas containing oil or chemicals. (Installing and operating it are prohibited)

1.2. Relevant Safety Regulations

The robot is designed according to ISO 10218-1:2006, the safety specifications for industrial robots, and also complies with ANSI/RIA R15.06-1999 regulations.

1.3. Safety Trainings

Workers who want to teach or inspect the robot should receive trainings on the use of the robot and the safety before using the robot. The safety trainings program includes the followings.

- Purpose and functions of safety systems
- Safety procedures for handling the robot
- Performance and potential risks of the robot or robot system
- Works related to special applications of the robot
- Concept of safety, etc.

1.4. Safety-Related Nameplates

1.4.1. Safety Symbols

In this manual, the following safety symbols are used for instructions for works.

Table 1-1 Safety Symbols

Symbol		Content
Warning		Indicates a very dangerous state, signifying that death or a severe injury or damage to the equipment may result from incorrect operation or handling. Please take precautions in operation and handling.
Mandatory		Indicates the items that must be implemented.
Prohibition		Indicates items that must not be performed.

1.4.2. Safety Nameplates

Nameplates, warning marks and safety symbols are attached to the inside and outside of the robot and control panel. The name marks and cable marks for the wire harness between the robot and control panel, and also for the cables inside and outside the control panel are provided.

All types of nameplates are surely attached to the clear locations of the manipulator and control panel to guarantee safety and their functions.

The paint marks for the robot area or the marks for dangerous areas indicated on the floor where the robot is installed should be clearly different in terms of shape, color, and style from other marks in the facility or machine where the robot system is installed.

It is prohibited to perform any act of damaging the nameplates, warning marks, safety symbols, name marks, wire marks, etc. clearly visible on the manipulator and controller, by removing, covering or painting them.

1.5. Definition of Safety Functions

Emergency Stop Function - 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 safety chain circuit of the robot. The emergency stop function is applied with priority over all other control functions of the robot. It 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 prevent other dangerous functions that are controlled by the robot from being used.

Safety Stop - EN ISO 10218-1:2006

A safety stop circuit needs to be configured, and, through this circuit, each robot should be connected with the safety systems and interlocks. The robot should have a number of electric input signals which can be used to connect external safety devices, such as safety doors, safety pads, and safety lights. These signals allow the robot itself and peripheral facilities to perform safety functions for the robot.

Speed Limit - EN ISO 10218-1:2006

In manual mode, the robot speed is limited to a maximum of 250 mm/s. The speed limit is applied not only to the Tool Center Point (TCP) but also to all robot's parts that are to be manually operated. In addition, it should be made possible to monitor the speed of the equipment mounted on the robot.

Restriction of the Operation Area - ANSI/RIA R15.06-1999

The operation area of each axis is restricted by the soft limit. In addition, the soft limit function also makes it possible to limit the operation areas of axes 1, 2, and 3 with mechanical stoppers.

Selection of the Operation Mode - ANSI/RIA R15.06-1999

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

1.6. Installation

1.6.1. Safety Fence

As there is a risk of collision between the robot and the workers while the robot is operating, install a safety fence to keep the workers from approaching the robot

As there is a risk of collision between the robot and the workers while the robot is operating, install a safety fence to keep the workers from approaching the robot closely. Otherwise, workers or other people may accidentally enter, causing an accident. Configure the system so that the robot stops when a person opens the door of the safety fence and approaches the facility while the robot is operating to inspect the robot or welding jigs or to perform tip dressing or tip changing.

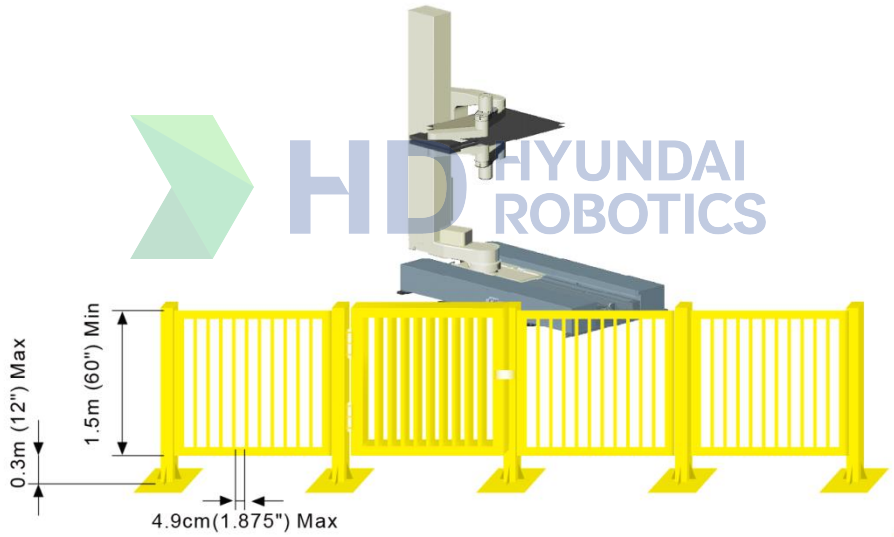

Figure 1.1 Recommended Sizes for the Safety Fence and Entrance Gate(Slot-Type Entrance Gate)

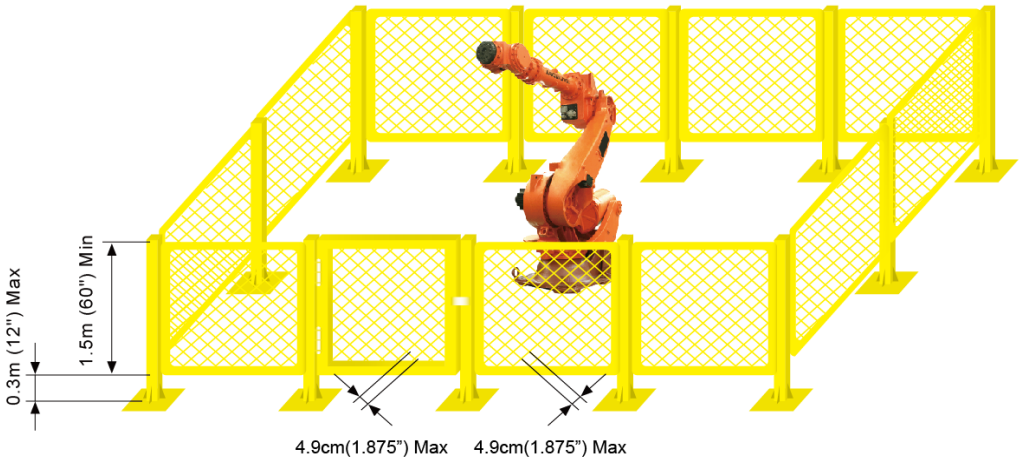

Figure 1.2 Recommended Sizes for the Safety Fence and Entrance Gate(Quadrangle-Type Entrance Gate)

(6) The safety fence should cover the operation area of the robot, and secure sufficient space so that there is no interference with the workers performing the teaching and maintenance works. In addition, make the safety fence sturdy so that it cannot be easily moved, and make it so that people cannot easily step over it.

(7) In principle, the safety fence should be installed in fixed manner. Please use a safety fence that does not have dangerous parts such as irregularities or sharp parts.

(8) An entrance gate should be installed to allow people to get inside the safety fence. A safety plug should be attached to the entrance gate, making it impossible to open the entrance gate unless the safety plug is pulled out. In addition, the wiring should be laid out in a way that when the safety plug is pulled out or the safety fence is opened, the robot can be put into the Operation Ready Off and Motor Off states.

(9) The wiring should be laid out in a way that if you want to operate the robot while the safety plug is pulled out, the robot plays back at a low speed.

(10) Install the robot's emergency stop button at a location where the worker can quickly press it.

(11) As a replacement for the safety plug in case of no installation of a safety fence, photoelectric switches, mat switches, etc. should be installed at all locations that fall within the operation range of the robot, so that the robot automatically stops when a person enters.

(12) It should be made possible to identify the operation area (dangerous area) of the robot by a method such as painting the floor.

1.6.2. Placement of the Robot and Peripheral Devices

Must place the robot and peripheral devices in the following ways.

(1) To connect the primary power of the controller or peripheral device, you should first check if the supply side power is off before proceeding with the work. There is a risk of electric shock because high voltage such as 220 V or 440 V is used as the primary power source.

(2) Attach the [Do Not Enter During Operation] sign to the entrance gate of the safety fence and inform the workers of its intent.

(3) Place the controller, interlock panel, and other operation panels in a way that they can be operated outside the safety fence.

(4) When installing an operation stand, attach an emergency stop button to it as well. It should be made possible to stop the robot in an emergency situation at any location from which the robot is operated.

(5) Make sure that the wires and pipes for the manipulator, the controller, the interlock panel, and the timer are not caught on the feet of workers or directly stepped on by the forklift. There is a risk of an accident in which workers are electrocuted or wires are disconnected.

(6) Place the controller, the interlock panel, the operation stand, etc., in a location from which the movement of the manipulator can be seen sufficiently. There is a risk of a major accident if the robot is malfunctioning in a location where you cannot see the operation of the robot or if a worker is carrying out works in such a place.

(7) If the operation area required for the robot is narrower than the area where the robot can operate, you should limit the operation area of the robot. Limiting it can be performed via soft limits, mechanical stoppers, etc. Even when the robot operates outside the limited area because of an abnormal operation such as improper operation of the robot, the robot will automatically stop because of the operation area limit function (refer to the Manipulator Maintenance Manual.)

(8) During welding, spatter may fall on the workers or surroundings, causing a burn or fire. Install light shields, covers, etc. to an extent where the movement of the robot body can be seen sufficiently.

(9) In the case of a device that shows the auto or manual mode of the robot, install the device conspicuously so that the operation status can be recognized even from a little distance away. A buzzer or alarm light is useful for the staring of the auto operation.

(10) Make sure there is no protruding part on the peripheral systems around the robot. If necessary, cover the systems with a cover, etc. In general, an accident may occur when a worker touches one of the systems, and a large-scale accident may occur when a worker falls by being surprised

by a sudden movement of the robot.

(11) Please do not design a system that requires putting your hand inside the safety fence to carry in or take out workpieces. Otherwise, there is a risk of an accident of being crushed or cut.

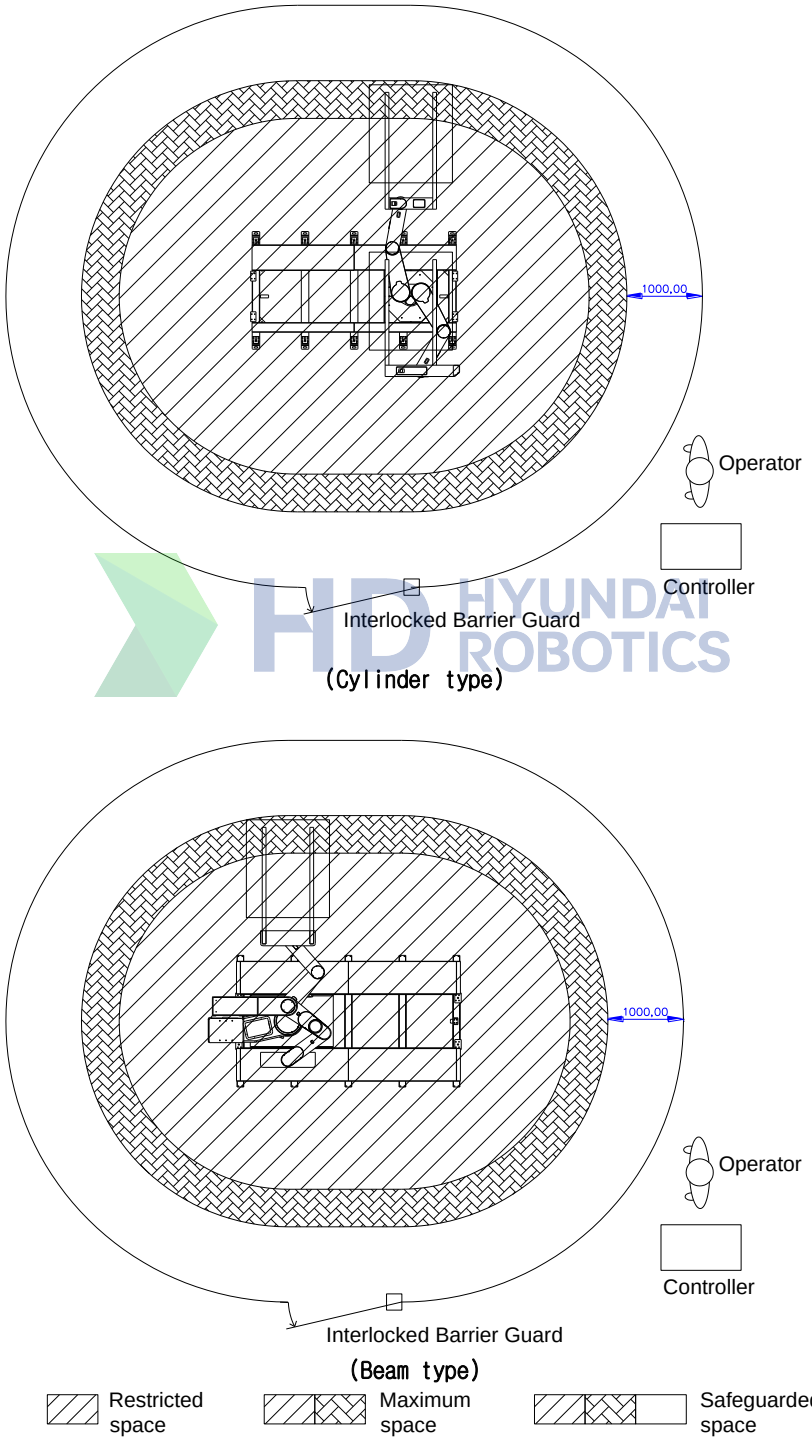

Figure 1.3 Placement of the Peripheral Systems of the LCD Robot, and the Workers

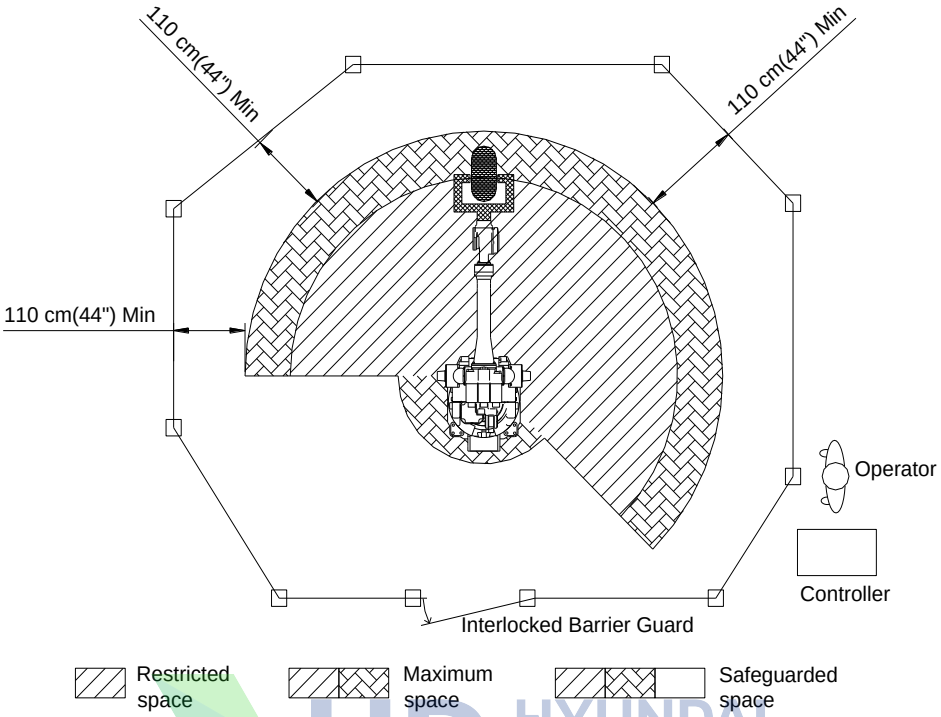

Figure 1.4 Placement of the Peripheral Systems of the Industrial Robot, and the Workers

1.6.3. Installation of the Robot

Must place the robot and peripheral devices in the following ways.

In order for the robot to fully perform its functions. it should be installed according to a pre-considered, planned foundation and placement. If the installation of the robot is in a poor condition, an error may occur in the relative position between the robot and the workpiece during operation, or vibration may occur, resulting in degradation of the quality of works performed by the robot. In addition, the service life of the robot may get shortened and a dangerous situation can occur. Therefore, when installing the robot, pay attention to the following items.

General Safety Matters

(1) To protect workers, the system should be designed and installed completely in accordance with the safety requirements specified by the laws and specifications of the country where the robot is installed.

(2) When required to install the robot on the ceiling or wall instead of the floor, you must consult with our engineers.

(3) Workers who use the robot should fully understand the contents described in application and supplementary manuals to skillfully operate and handle the industrial robot.

(4) Workers who install the robot should be able to apply safety instructions if problems occur during installation.

(5) System suppliers should ensure that all circuits using safety functions surely perform the functions.

(6) The main power supplied to the robot should be installed so that it can be cut off from outside the operation area of the robot.

(7) The system suppliers should clearly ensure that all circuits using the emergency stop function perform the function in a safe manner.

(8) For a case that requires stopping the robot abruptly, the emergency stop button should be located in a place where workers can easily access it.

Technical Safety Matters

(1) Should take into consideration the size of the manipulator and the operation range to ensure that there is no interference with peripheral devices.

(2) Avoid installing the robot in a place where direct sunlight reaches, humidity is high, oil or chemicals are present, or a lot of metal powder or explosive gas are in the air.

(3) Install the robot where the ambient temperature is within the range of 0℃–45℃.

(4) Secure enough space to easily disassemble and inspect the robot.

(5) Install a safety fence and prevent people from entering the operation range of the robot.

(6) Make sure that there is no obstacle in the operation area of the robot.

(7) When required to install the robot in a place exposed to direct sunlight or near a heating element, you should take measures in consideration of the thermodynamic state of the controller.

(8) When required to install the root in a place where there is a lot of dust such as metal powder in the air, you should take separate measures.

(9) Install the robot in a way that the welding current never flows to the robot. In other words, there must be insulation between the spot gun and the wrist of the robot.

(10) Considering that grounding is very important in preventing a false operation because of noise and an electric shock, you should carry out installation as follows.

① A dedicated grounding terminal should be installed, and its grade must be higher than class 3 grounding (If the input voltage of the robot controller is 400 V or higher, special class 3 grounding or higher should be applied.)

② The grounding wire should be connected to the grounding bus bar inside the control panel.

③ When the manipulator is installed, if it is directly grounded to the floor by an anchor, etc., the controller side and the manipulator side constitute two grounding points, conversely causing a closed circuit to be formed with a risk of a false operation because of noise conversely. In this case, connect the grounding wire to the base of the manipulator and do not connect it to the controller side. Also, if vibration occurs when the robot is stopped, it is highly likely that the grounding is incomplete or a closed circuit has formed. Check the grounding again.

④ When a transformer-embedded gun is used, there is a risk of falling because the primary power cable is directly connected to the spot gun. In this case, to protect the control panel and prevent an electric shock, you should connect the grounding wire directly to the manipulator base and do not connect it to the controller.

1.6.4. Space for Installing the Robot

Install the robot after securing sufficient space for preserving the manipulator, the controller, and other peripheral systems. To install the manipulator and controller, please secure the above mentioned installation area. Install the controller in a place outside the safety fence where the manipulator can be easily seen and works can be carried out safely.
Install the robot so that maintenance work can be done easily when the door of the controller is opened. The specifications of the controller may differ depending on the type of the controller (for more details, please refer to the Maintenance Manual.)

1.7. Safety Works in Operating the Robot

Must follow safety work procedures to prevent safety accidents. In no circumstance, do not change or ignore the safety systems and circuits, and be careful of electric shocks.
In auto mode, all normal works must be performed from outside the safety fence. Before carrying out works, you must ensure that there is no one in the operation area of the robot.

1.7.1. Safety Measures for Handling the Robot

Please observe the following measures because safety is very important when operating the robot.

(1) The workers who operate or may operate the robot, and the supervisors must fully recognize the safety and the function of the robot by taking prescribed trainings. The robot must not be operated by anyone other than those who have been so trained and designated.

(2) Must wear a safety hat, protective glasses and safety shoes.

(3) The work must be done by two people. One person performs teaching and the other monitors form the operation panel. One person should be ready to press the emergency stop switch at any time, and the other one should proceed with the works quickly while paying much attention in the operation area. In addition, workers should check the evacuation routes in advance before the work.

(4) First, ensure that there is no worker within the operation area of the robot, and then turn on the power.

(5) In principle, works including teaching should be performed from outside the operation range of the robot. However, when required to stop the equipment and carry out works within the operation range, you need to enter the range while brining in the key switch or safety plug that is used to change to auto operation. It is necessary to ensure that other workers do not mistakenly switch the robot to auto operation. In addition, pay special attention to the operational direction of the robot in preparation for an unexpected situation such as false operations or wrong conditions.

(6) In preparation for an unexpected falling of the axis, you must be careful not to place your body in the direction of the falling of the axis or within the range where you may get crushed.
As there is a risk of the axis falling because of the slippage of the motor brake, the failure of the balance, etc., you should check before performing the teaching work. When it comes to the gas spring, you must check that the proper pressure is maintained before carrying out the teaching work.

(7) A supervisor should observe the following items.
① Position yourself in a place where you can see the entire robot and devote yourself to the monitoring work.

② When there is an abnormality, press the emergency stop button immediately.
③ Make sure that no one other than those involved in the work is within the operation range.

(8) During the manual operation, the speed will be limited to a maximum of 250 mm/sec.

(9) When performing the teaching work, you should put a sign saying [Teaching in Progress.]

(10) When entering inside the safety fence, the workers must pull out the safety plug and bring it with them.

(11) Do not use equipment that may cause noise in or around the place where teaching work is performed.
(12) Handle the teach pendant button while looking at the teaching point with your naked eyes, not by handling it just relying on the feeling of your hands.

(13) These are the maintenance parts to be prepared when you purchase multiple robots.

(14) During a teaching work, you should fully check under your feet. In particular, secure a safe area that you can set foot on when performing the teaching work at heights (2 m or higher.)

(15) Take following measures when an abnormality occurs.

① If there is an abnormal operation spotted, press the emergency stop button immediately.
② When checking for an abnormality following an emergency stop, you must check the state of the stopping of the related facilities.
③ If the robot automatically stops because of an abnormality in the power supply, you should first confirm that the robot has stopped completely and then investigate the cause and take measures.
④ If the emergency stop system does not perform its functions, you should cut off the main power immediately, investigate the causes, and take measures.
⑤ No one except for the designated person should investigate the cause. Restarting after an emergency stop should be performed in sequence after the cause of the error is clearly identified and measures are taken.

(16) Create appropriate work regulations regarding not only the methods to drive and operate the robot and robot but also the measures to take against abnormalities in consideration of the location of installation and contents of works. In addition, progress the works in accordance with the work regulations.

(17) Precautions when the robot has stopped
You must avoid blindly approaching the robot assuming it is stationary. There are many cases where a person approached a robot the person thought was stationary, but the robot suddenly moved, resulting in a disaster. When the robot is stopped, it is in the following states.

Table 1-2 State of the robot

No.	State of the robot	Driving source	Accessibility

1	In temporary stop (attributable to a minor abnormality or the temporary stop switch)	ON	X
2	In emergency stop (attributable to a major abnormality, the temporary stop switch, or the safety door)	OFF	O
3	Waiting for an input signal from a peripheral system (START INTERLOCK)	ON	X
4	Playback being completed	ON	X
5	In standby	ON	X

Even when access is possible, you should not neglect to pay attention to any possibility of sudden movements. In any case, you must avoid approaching the robot without preparing for an emergency.

■ **When required to open the entrance gate to take a measure against a minor abnormality during the temporary stop (when detecting the contact with the nozzle, deposition, abnormal arc, etc.,) you should take the same measures as those for entering for the teaching work.**

(18) After completing the operation of the robot, you should clean the inside of the safety fence and make sure that no tools, oil, foreign substances, etc. are left there. If the operation area is dirty with oil or littered with tools left, an accident such as a falling over may be caused. Always make it a habit to keep things organized and tidy.

1.7.2. Safety Measures for Operating the Robot for Testing

Please observe the following measures because safety is very important when operating the robot for testing.

When the test operation is conducted, there may be design errors, teaching errors, or manufacturing defects in the entire system including the teaching program, jigs, and sequences. Therefore, it is necessary to work with more safety awareness in performing the test operation. In some cases, safety accidents may occur because of complex factors.

(1) Before operating the robot, check the functions of the switches and signals that are designed to stop the robot, such as the emergency stop switch and the stop switch. After that, check the operations related to the detection of abnormalities. First, it is most important to check all signals that are designed to stop the robot. When an accident is predicted, the most important thing is to stop the robot.

(2) When operating the robot for testing, operate it at low speed using the speed variation function and check the operation while operating the robot repeatedly for more than one cycle. If a problem is found, please correct it immediately. After that, increase the speed sequentially (50% → 75 % → 100 %) and operated the robot repeatedly for more than one cycle at each speed to check the operation. If the robot is operated at high speed from the beginning, it may cause a severe accident.

(3) It is impossible to foresee what problems may arise during the test operation. During the test operation, never go inside the safety fence. Because of low reliability of the system, there is a high possibility that unexpected accidents occur.

1.7.3. Safety Measures for Auto Operation

Please observe the following measures because safety is very important when operating the robot in auto mode

(1) Put a [Do Not Enter During Operation] sign on the entrance gate of the safety fence, and strictly ask workers to refrain from entering during the operation. If the robot is stopped, you may go inside the safety fence after judging the situation

(2) When required to start auto operation, you must check whether there is a worker inside the safety fence. If you work without checking for the presence of a worker, an accident involving a person may occur.

(3) When required to start auto operation, start it after confirming that the program number, the step number, the mode, the selection for staring, etc. are all in a state that auto operation can be performed. If you start auto operation while a different program or step is selected, the robot may perform an unexpected operation, causing an accident.

(4) When required to start auto operation, start it after confirming that the robot is in a position that enables the start of the auto operation. Check whether the program number or step number matches the position of the robot. Even when the program number or step number is correct, if the robot is in a different position, an accident may occur because of an operation that is different from usual operations.

(5) When required to start auto operation, you should be prepared to press the emergency stop switch immediately. If an unexpected operation of the robot or an unexpected situation occurs, press emergency stop switch immediately.

(6) Identify the operation path, operation status, operation sound, etc. of the robot in a way to judge whether there is any abnormal state. Robots may suddenly malfunction or cause abnormalities. However, there are cases where the robot shows some signs before it fails. To foresee a failure in advance, you should grasp the state of the normal operation of the robot.

(7) If you identified any abnormality, immediately perform an emergency stop and take appropriate measures against the abnormality. If the robot is used without proper measures taken, not only the production will stop but also a severe failure that may cause a major accident that involves a person may occur.

(8) When required to complete the actions after an abnormality has occurred, do not operate the robot while a worker is inside the safety fence. Otherwise, because of low reliability, an unexpected accident, such as occurrence of abnormality, may occur.

1.8. Safety Measures For Going Inside the Safety Fence

Please observe the following measures because safety is very important when going inside the safety fence.

Even when the robot moves at a slow speed, its weight is quite heavy and its force is very powerful. When entering the safety area of the robot, you must comply with the safety regulations of the concerned country.

Workers should always be aware that the robot may operate in an unexpected manner. Even when the robot stops moving for a moment, it can move quickly the next moment. The workers should know that the robot can change its path and move according to an external signal without giving a warning. If you want to stop the robot during the teaching or test operation, you must be able to stop it immediately with a teach pendant or operation panel of the controller.

When entering the operation area of the robot through the safety gate, you must bring the teach pendant with yourself. By doing so, you should prevent others from operating the robot. You must hang a sign on the operation panel of the controller to indicate that the robot is currently being operated.

When entering the operation area of the robot, you must fully understand the following items

(1) No one except for the person performing the teaching work should enter the operation area of the robot.

(2) The operation setting mode of the controller should be in manual mode on the operation panel of the controller.

(3) Always wear certified working clothes. (No loose, arbitrarily selected clothes.)

(4) Do not wear gloves when operating the controller.

(5) Do not let your underwear, shirts, ties, etc. to come out of the working clothes.

(6) Do not wear large jewelry such as earrings, rings, necklaces, etc.

(7) Must wear safety shoes, safety hat, and protective glasses. If necessary, you should wear safety gear such as safety gloves.

(8) Before operating the robot, check if the emergency stop circuit works properly to turn off the motor when the emergency stop switches on the control panel and teach pendant are pressed respectively.

(9) Work in a posture that makes you face the manipulator.

(10) Follow pre-determined work procedures.

(11) Assume that a robot may unexpectedly charge at you, and prepare an evacuation method or place for evacuation accordingly.

1.9. Safety Measures for Maintenance and Inspection

1.9.1. Safety Measures for Maintaining and Inspecting the Controller

Please observe the following safety measures when maintaining and inspecting the robot controller.

(1) Maintenance and inspection works should be performed only by those who have received special maintenance trainings and fully understand the relevant contents.

(2) Progress the works according to the procedures for maintaining and inspecting the controller.

(3) Must perform the maintenance and inspection works safely after securing a passage or a place to avoid danger by checking the safety of the surroundings.

(4) Must turn off the power when required to perform daily inspections, repairs, or replacement of parts of the robot. In addition, put a warning sign such as [Do Not Supply Power] on the primary power source so that other workers cannot turn on the power carelessly.

(5) Use only the designated replacement parts.

(6) When required to open the controller door, you must turn off the power and then wait for about three minutes before starting the work.

(7) If sufficient illumination is not secured when maintaining and inspecting the inside of the controller, you should use external lights.

(8) Do not touch the heat radiation plate and regenerative resistor of the servo amplifier because they generate excessive heat.

(9) After completing maintenance, you should check if tools or other things are left inside the controller and then securely close the door.

1.9.2. Safety Measures for Maintaining and Inspecting the Robot System and Manipulator

Please observe the following safety measures when maintaining and inspecting the robot system and manipulator

(1) Please refer to the safety measures for repairing or inspecting the controller.

(2) When maintaining and inspecting the robot system or manipulator, you should progress the work according to the instructed procedures.

(3) Must turn off the main power of the controller. In addition, put a warning sign such as [Do Not Supply Power Input] on the primary power source so that other workers cannot turn the power back on carelessly.

(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. Actions To be Taken after Maintenance and Inspection

Please observe the following actions after maintenance and inspection

(1) Inspect whether the wires or parts inside the controller are normally connected.

(2) After completing the maintenance work, you should check whether tools are left in or around the controller, manipulator and the system and then make sure that they are kept organized and tidy. Must close every door.

(3) Do not power on the robot if a problem or critical defect is found.

(4) Before supplying the power, you should ensure that there is no worker in the robot operation area and that you are in a safe place.

(5) Turn on the power circuit breaker inside the control panel.

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

(7) Operate the robot at low speed.

1.10. Safety Functions

1.10.1. Operation of the Safety Electric Circuit

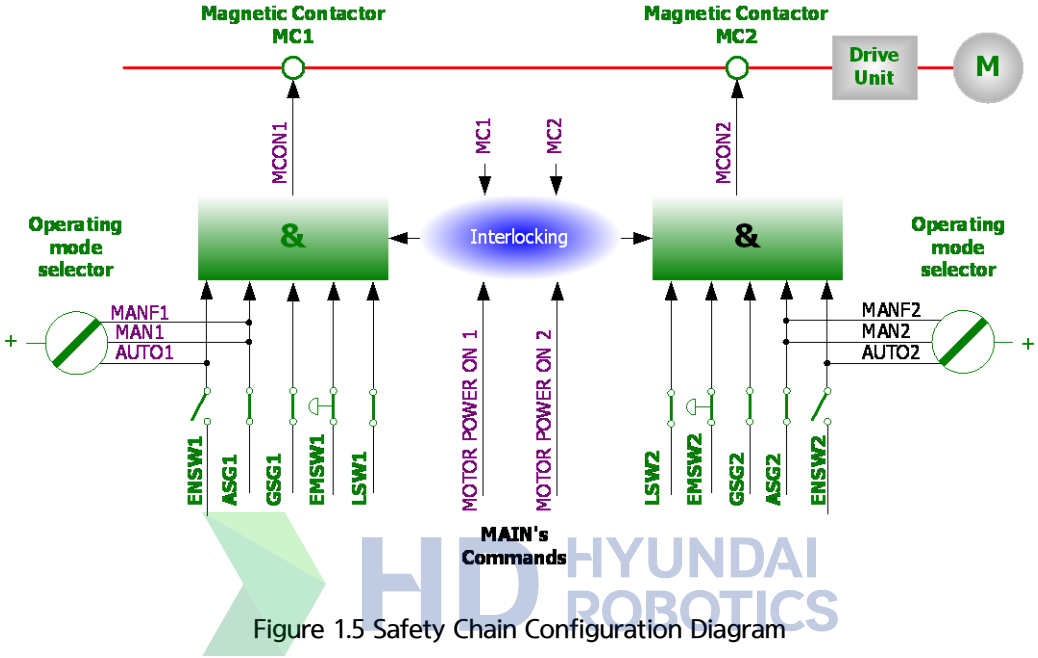

Figure 1.5 Safety Chain Configuration Diagram

The safety system of the robot is configured with a dual safety electric circuit that continuously monitors its status. If an error is detected, the motor power will be cut off immediately and the motor brake will be operated. All switches of the dual safety electric circuit should be connected to recover to the motor On state. If any one of the switches of the dual safety electric circuit is shorted, the contactor of the motor will be disconnected and the brake will be activated to stop the robot. In addition, when the dual safety electric circuit is cut off, an interrupt call will be sent to the controller to identify the cause of the interrupt.

During the operation, the safety control circuit will be based on the dual safety electric circuit in which the controller and motor ON mode interact with each other. In order for the robot to recover to the motor On mode, the multiple switches comprising the safety electric circuit should be connected entirely. Motor On mode means that the drive current is supplied to the motor. If any contact point in the dual safety electric circuit is broken, the robot always returns to motor Off mode. Motor Off mode means that the driving current is not supplied to the motor of the robot and the motor brake is activated. The status of the switches is displayed on the teach pendant (refer to the “I/O Monitoring” screen in the Operation Manual.)

Safety Electric Circuit

The emergency stop buttons on the controller control panel and teach pendant respectively and the emergency stop buttons installed on the external facilities are included in the dual safety electric circuit. The safety systems (safety plugs, safety area entry stopping systems, etc.) that operate in auto operation mode can be installed by the user. The signals from the safety systems will be ignored in manual operation. The function of stopping by the safety systems (general safety stop systems) can be used in all operation modes when the user connects them. In other words, in the auto operation mode, all safety systems (doors, safety mats, safety plugs, etc.) will be operated so that no one can enter the safety area of the robot. Signals from the safety systems will be generated even in manual operation mode, but the controller will ignore those signals for the sake of teaching the robot and allowing the robot to operate continuously. In this case, the maximum speed of the robot will be limited to 250 mm/s. In other words, this safety stop function is designed to secure a safe area around the manipulator while a worker approaches the robot to preserve and teach it.

When the robot is stopped by the limit switch, you can change the position of the robot by jogging the robot with the operation keys of the teach pendant in parameter setting mode (Constant setting mode means the state of entering the 『[F2]: System』 menu in manual mode.)

Never ignore, modify or change the safety electric circuit in any way.

1.10.2. Emergency stop

An emergency stop should be operated when a person or equipment is in a dangerous area. All safety control systems such as the emergency stop switch on the controller operation panel, should be easily accessible from outside the safety area.

State of Emergency Stop

The robot will operate as follows when the emergency stop button is pressed.
The robot will stop immediately in any case.

- The power of the robot servo system will be cut off.
- The robot motor brake will operate
- The screen of the teach pendant will display the emergency stop message.

The emergency stop can be performed in the following two ways.

(1) Emergency stop by the operation panel and by the teach pendant (default)

The emergency stop buttons are on the controller operation panel and teach pendant respectively.

(2) Emergency stop by an external system

An external emergency stop system (switch, etc.) can be connected to the safety electric circuit based on the standard for application of the emergency stop circuits. (refer to System Board in “Basic Configuration of the Controller”). At this time, the wiring should be laid out in a way that the emergency stop can be in the “Normal On” state, and you must check its operation during the test operation.

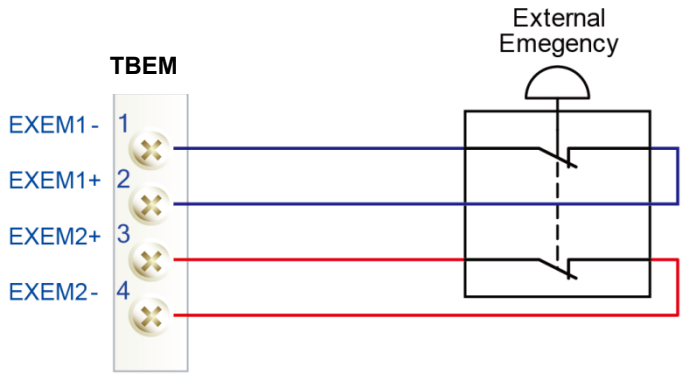

Figure 1.6 Connection of an external emergency stop switch through TBEM, the system board terminal block.

1.10.3. Operation Speed

To teach the robot, the operation mode switch should be in manual position. At this time, the maximum speed of the robot will be limited to 250 mm/s.

1.10.4. Connection of Safety Systems

External safety systems such as safety lights, safety curtains, safety plugs, safety mats, etc., which are designed by the system designer for external use, are to be connected to the safety electric circuit of the controller in a way that they can be interlocked with the controller. These external safety systems are used as safety systems when normal programs are executed in auto mode.

1.10.5. Restriction of the Operation Area

When applying a robot, if you judge that a certain operation of the robot is not necessary, the robot operation area can be limited to secure a sufficient safety area. When there is collision between the robot with an external safety system such as a safety fence, this function will minimize damage. The operation range of axes 1, 2 and 3 of the robot is controlled by mechanical stoppers or electrical limit switches. If the operation range is changed by a mechanical stopper or electrical limit switch, the operation range limit parameter should be also changed in software. If necessary, the movement of three wrist axes can also be restricted. The limits of the operation area of each axis can be changed by the user. At the time of shipment, the robot is set to the maximum operation range.

- **Manual mode: Maximum speed is 250 mm/s**
  In manual mode, it is made possible that the worker can enter the safety area of the robot by the operator's own choice.

- **Auto mode: The robot can be operated with a remote operation system.**
  Safety systems such as an entrance gate and a safety mat will be operating.
  No one should be allowed to enter the area of the safety systems of the robot.

1.10.6. Monitoring Functions

(1) Motor monitoring function
The sensor inside the motor protects the motor from being overloaded.

(2) Voltage monitoring function
When overvoltage or undervoltage occurs, the servo amplifier module turns off the input from the power switch to the servo amplifier to protect the amplification element.

1.11. Safety related to End Effectors

1.11.1. Gripper

(1) When required to use a gripper to hold a workpiece, there should be preparatory measures for unexpected falling of the workpiece.

(2) When required to mount a device to an end effector or arm, you should use the bolts of specified sizes in specified counts, and use a torque wrench to fully tighten them with the specified torques. Also, the bolts that are not rusted or dirty should be used.

(3) Manufacture the end effectors considering that it can be used within the allowable load range of the writs of the robot. In addition, the end effectors should be structured in a way that the gripped object will not be released or dropped even when the power or air supply is stopped and also that the corners or protruding parts of it are surely treated to prevent damage to people and objects.

1.11.2. Tools/Workpieces

(1) It should be made possible to safely change a tool such as a milling cutter. Until the cutter stops rotating, the safety systems should surely perform their functions.

(2) The tool should be designed so that the workpiece does not fail even when a sudden power outage or control failure occurs. In manual operation mode, it should be made possible to detach the workpiece.

1.11.3. Pneumatic/Hydraulic Systems

(1) Special safety regulations apply even to the pneumatic and hydraulic systems.

(2) These systems may have residual energy even after they stopped, which requires your special attention. When required to repair the pneumatic and hydraulic systems, you must remove the pressure inside them beforehand.

1.12. Responsibilities

The robot system is manufactured in accordance with the latest technical standards and approved safety specifications. Nevertheless, during use, the robot system may collide with surrounding facilities, which may cause an accident that threatens the life of the operator or injures the arms and legs of the operator.

The robotic system must be used in a technically perfect condition for its intended use and must be used by operators capable of paying attention to safety with full awareness of the risks involved in operation. The robot system should be used in accordance with the operation instructions and manuals supplied with the robot system. Never use the safety-related functions of the robot system for any other purpose in no case.

To use the robot system for a purpose other than the designed purpose or for an additional purpose, please review whether the use complies with the intended usage of the design. The manufacturer will not be held liable for any damage or accident caused by such misuse. The users are solely responsible for the misuse. When operating the robot system within the intended usage of the design, you must fully understand the operation manual, which is the standard document for operating the robot.

Do not use the robot system until the machines or systems included and used in the robot system comply with the EU machinery standards instructed by 98/37/EC (2006/42/EC) and US OSHA.

The standards listed below are related 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 are responsible for the accidents caused by ignoring these instructions. In addition, the manufacturer is not responsible for the damage caused by the equipment supplied by the user, the equipment not included in the contract with the manufacturer, or the equipment the user arbitrarily configured around the robot system. The user is solely responsible for all risks associated with such equipment.

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2 Specifications

2.1. Format for the Robot Mechanical Part

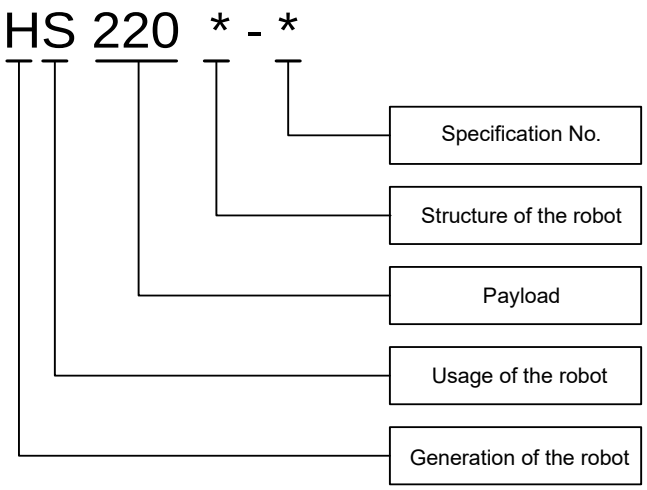


Figure 2.1 Format for the Robot Mechanical Part

2.2. Location of the Robot Nameplate

The nameplates shows the robot type, the serial number, and the manufacture date
The nameplate is located on the bottom surface (left or right) of the manipulator as shown in the figure below.

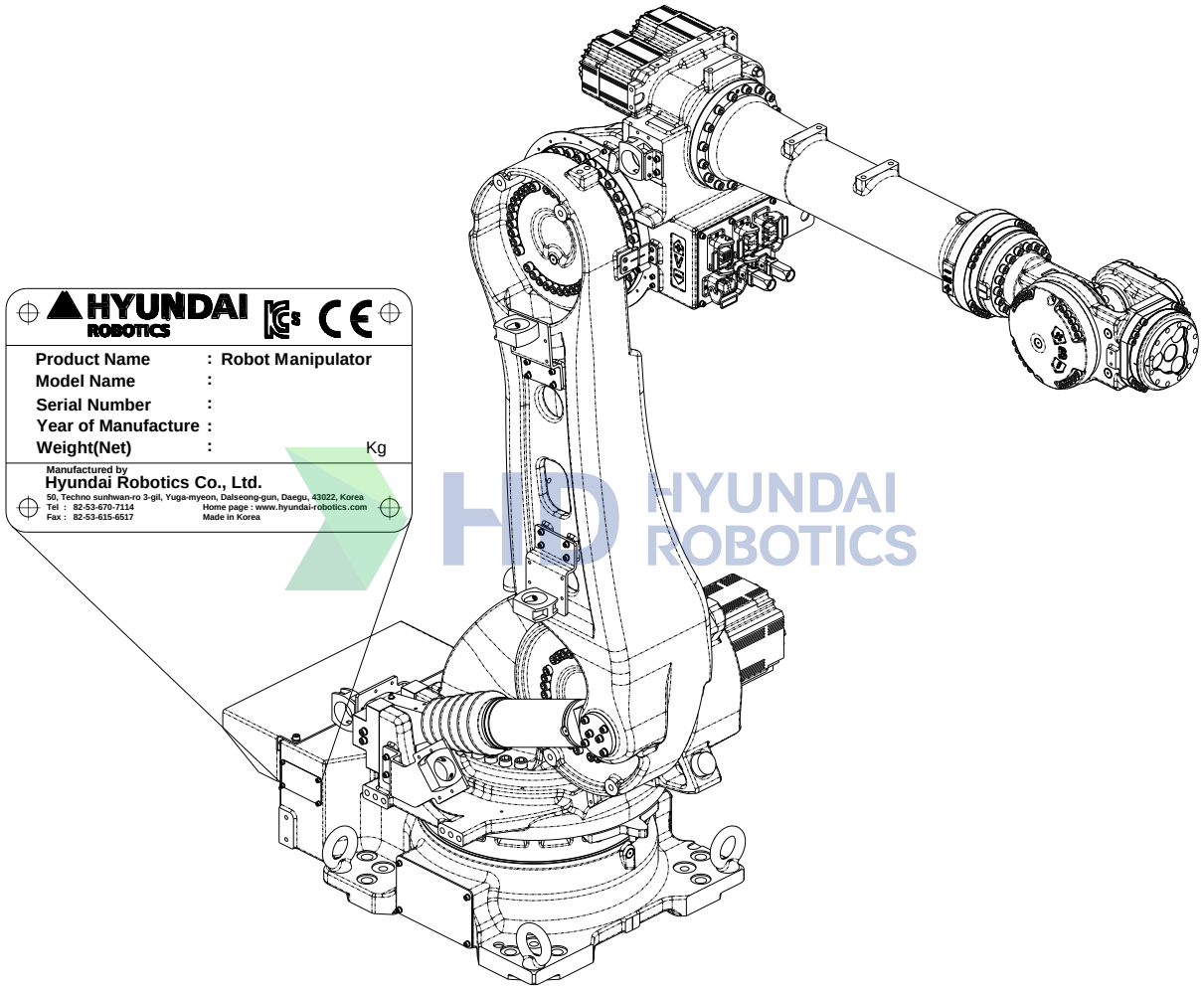


Figure 2.2 Attachment Location of the Robot Nameplate

2.3. Basic Specifications

Table 2-1 Basic Specifications by Model

Item				Specifications		
Model				HS160L	HS180	HS220
Payload				160 kg	180 kg	220 kg
Structure				Multi-joint type		
Degree of freedom				6 (6-axes S, H, V, R2,B, R1)		
Driving method				AC servo		
Installation type				Floor mounting		
Maximum operation range	Main axes	S	Swivel	±3.142 rad (±180°), ±3.107 rad (±178°) LS Option1		
		H	Forward and backward	+2.705 ~ 0.175 rad (+155° ~ +10°)		
		V	Upward and 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 axes	R2	Rotation 2	±6.284 rad (±360°)		
		B	Bending	±2.234 rad (±128°)		
		R1	Rotation 1	±6.284 rad (±360°)		
Maximum speed	Main axes	S	Swivel	2.094 rad/s (120°/s)		2.094 rad/s (120°/s)
		H	Forward and backward	2.007 rad/s (115°/s)		1,833 rad/s (105°/s)
		V	Upward and downward	2.007 rad/s (115°/s)	2.182 rad/s (125°/s)	1.920 rad/s (110°/s)
	Wrist axes	R2	Rotation 2	3.037 rad/s (174°/s)	3.229 rad/s (185°/s)	2.531 rad/s (145°/s)

[1]LS Option: The maximum operation angle when the limit switch to restrict the angle is attached.

Item				Specifications		
		B	Bending	3.002 rad/s (172° /s)	3.054 rad/s (175° /s)	2.531 rad/s (145° /s)
		R1	Rotation 1	4.538 rad/s (260° /s)	4.625 rad/s (265° /s)	3.840 rad/s (220° /s)
Payload				1568 N (160 kg)	1764 N (180 kg)	2156 N (220 kg)
Wrist torque		R2	Rotation 2	1079 N·m (110 kgf·m)		1422 N·m(145kgf·m)
		B	Bending	1079 N·m (110 kgf·m)		1422 N·m(145kgf·m)
		R1	Rotation 1	566 N·m (58 kgf·m)		770 N·m(79 kgf·m)
Position repeatability accuracy				±0.15 mm	±0.11 mm	
Manipulator weight				985 kg	955 kg	
Installation environment	Ambient temperature			0 ~ 45℃ (273 ~ 318 K)		
	Relative humidity			20 ~ 85 %RH		
	Vibration			0.5 G or below		

2.4. External Dimensions of the Manipulator and the Operation Area

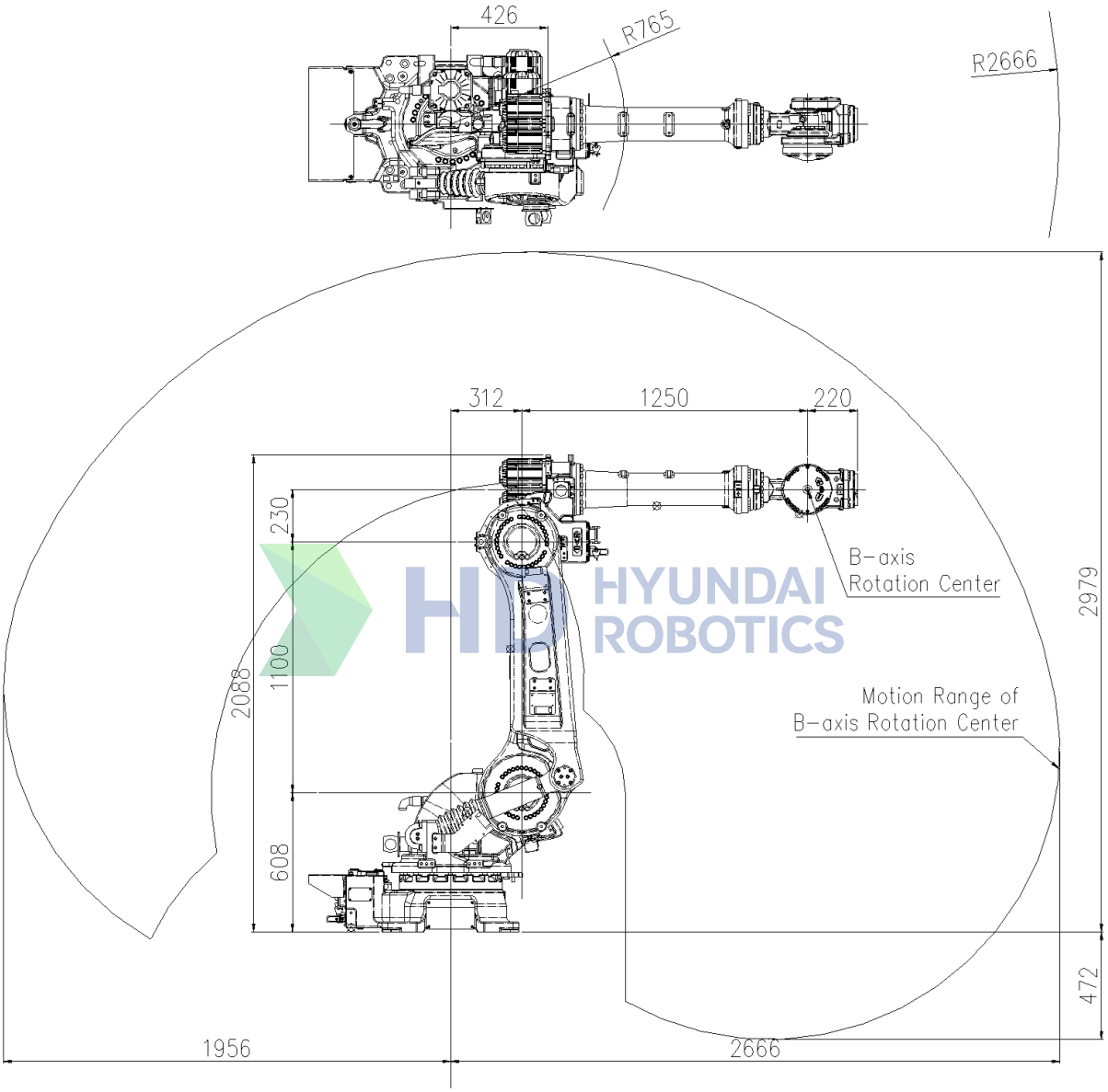


Figure 2.3 External Dimensions of the Manipulator and the Operation Area(HS180/HS220)

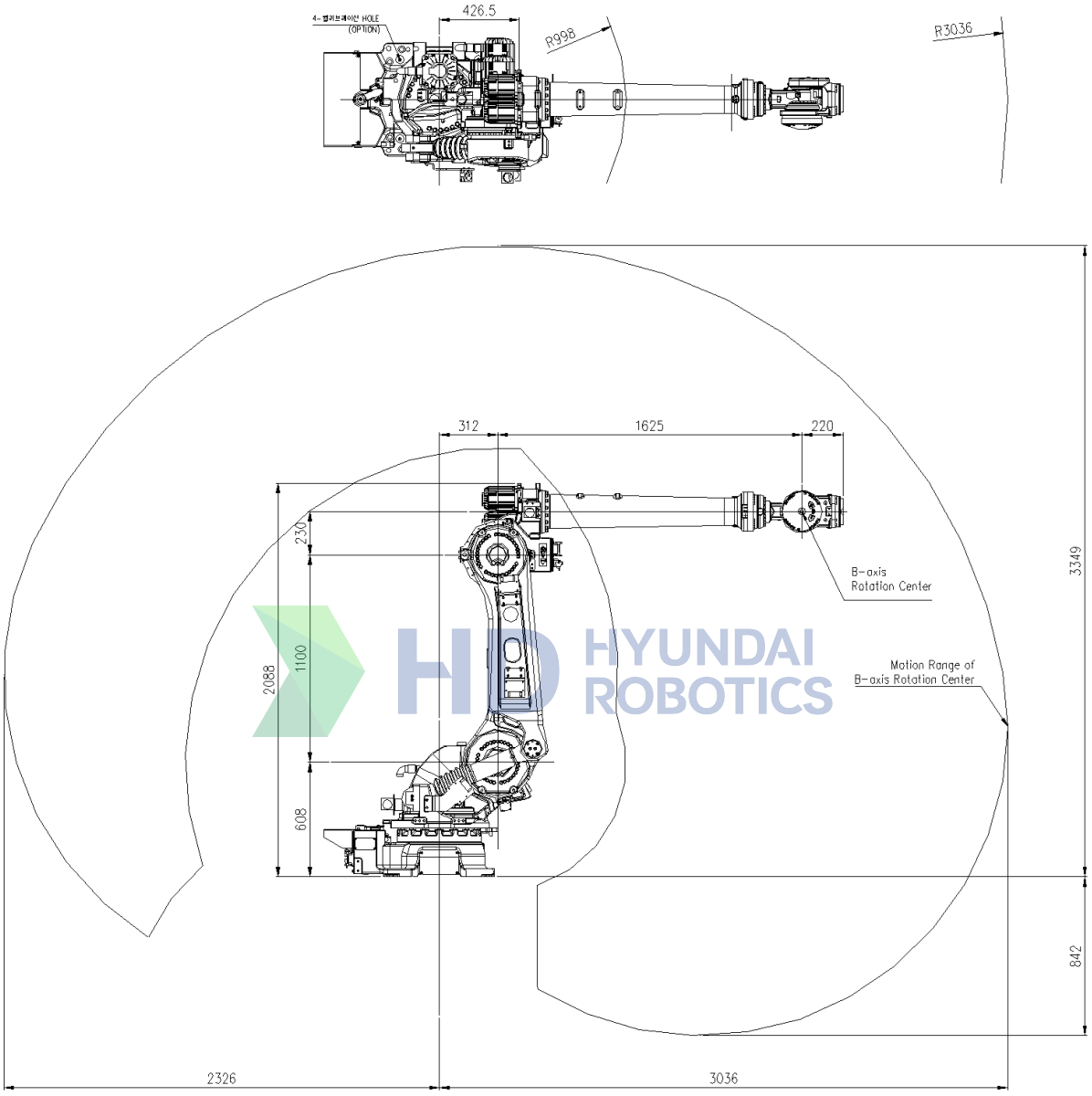


Figure 2.4 External Dimensions of the Manipulator and the Operation Area(HS160L)

2.5. Names of Operation Axes

Table 2-2 Rotational Direction of Each Axis

Axis name	Operation	Button on the teach pendant	
Axis 1 (S)	Swivel	X+(S+)	X-(S-)
Axis 2 (H)	Forward and backward	Y+(H+)	Y-(H-)
Axis 3 (V)	Upward and downward	Z+(V+)	Z-(V-)
Axis 4 (R2)	Rotation 2	RX+(R2+)	RX-(R2-)
Axis 5 (B)	Bend	RY+(B+)	RY-(B-)
Axis 6 (R1)	Rotation 1	RZ+(R1+)	RZ-(R1-)

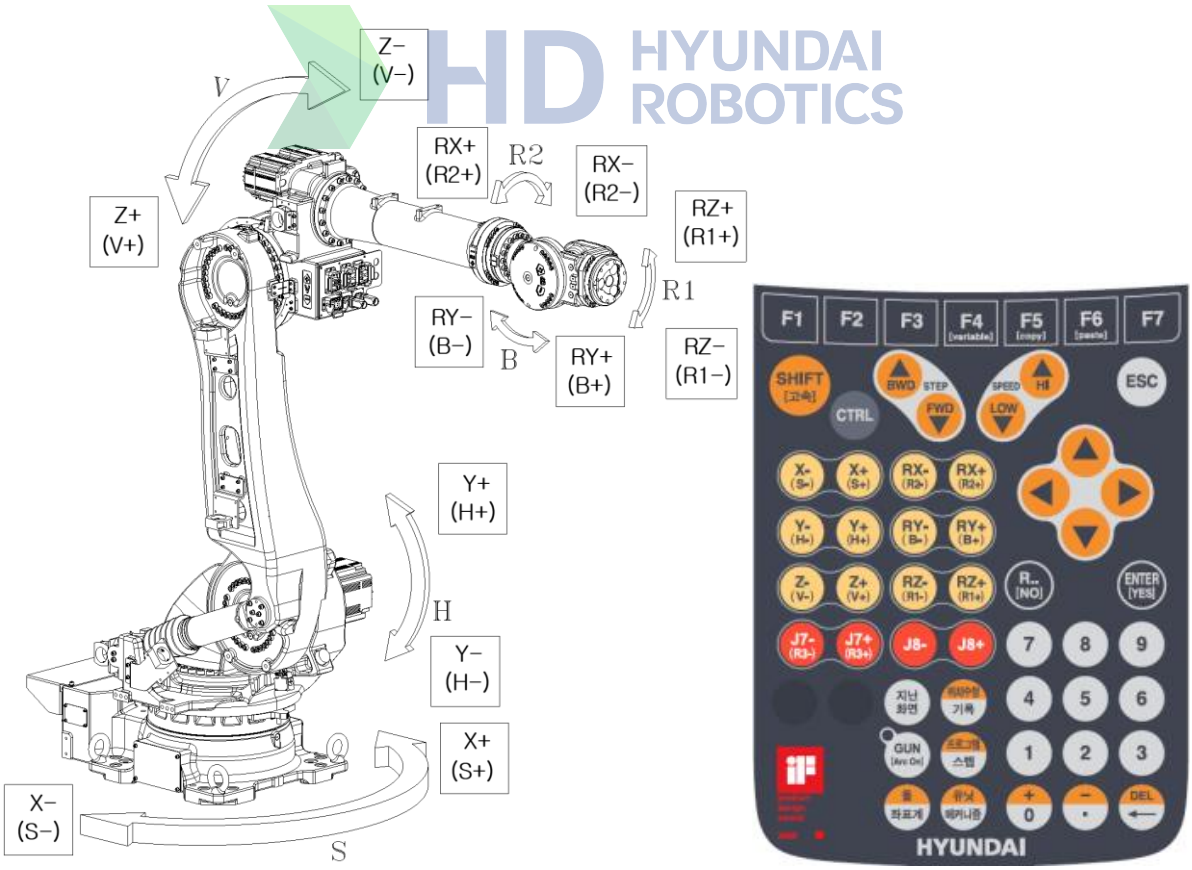


Figure 2.5 External Appearance of the Manipulator and the Operation Axes

2.6. Detailed Diagram of the Wrist Axis Attachment Surface

Use bolts of PCD 125 when attaching a working tool to the flange at the front end of the wrist axis.

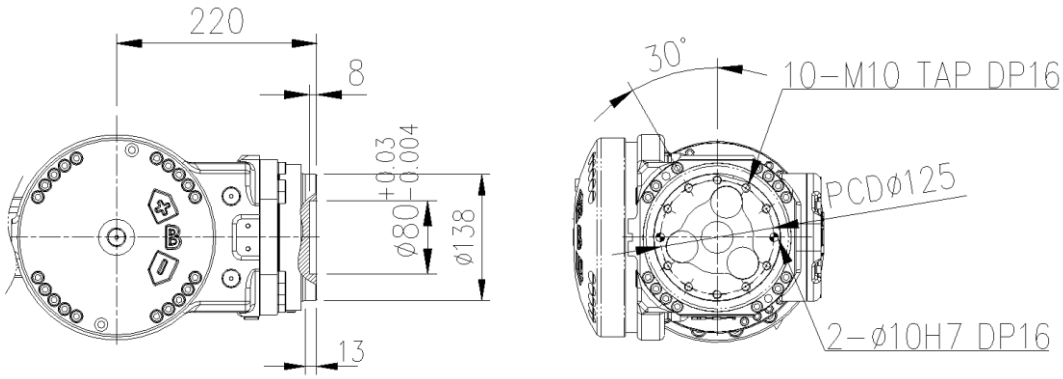


Figure 2.6 Detailed Diagram of the Wrist Axis Attachment Surface

2.7. Detailed Diagram of the Attachment Surface on the Top of the Arm Frame

There are taps machined on the tops of the arm frame and arm pipe of the robot to allow a peripheral device to be attached.
Attach a peripheral device (valves, etc.) within the range marked as ▦.

[Precautions in handling]

Attach a peripheral device to either the upper part of the arm frame or the upper part of the arm pipe. Perform attachment in a way that the central position of the load falls within the range marked as ▦.

- Maximum load on the arm pipe: 20 kg

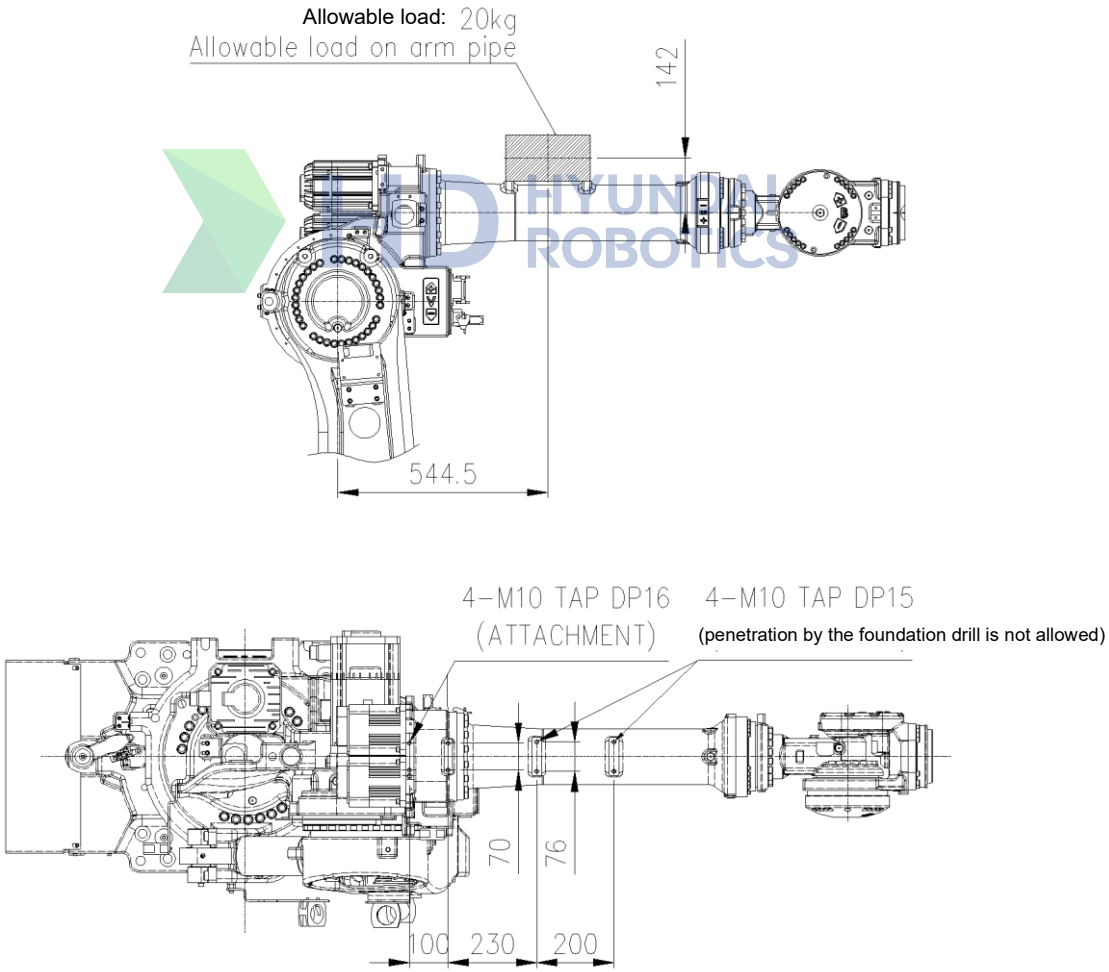


Figure 2.7 Detailed Diagram of the Attachment Part on the Top of the Arm Frame (HS180/HS220)

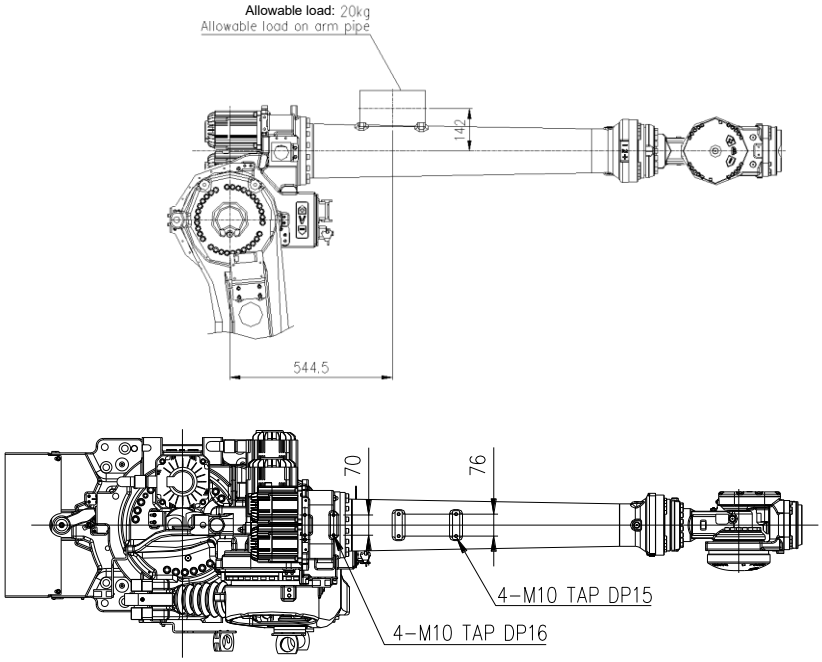


Figure 2.8 Detailed Diagram of the Attachment Part on the Top of the Arm Frame (HS160L)

2.8. Wiring and Piping Diagrams for Applications

On the manipulator, there are connectors and air units for connecting additional equipment.
The following figures show the user application connectors.

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

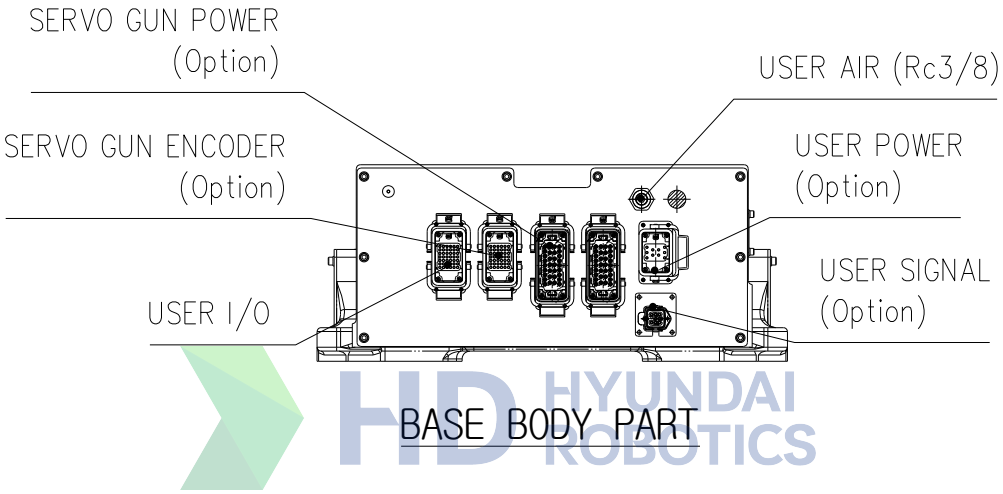


Figure 2.9 Wiring and Piping Diagrams for Applications

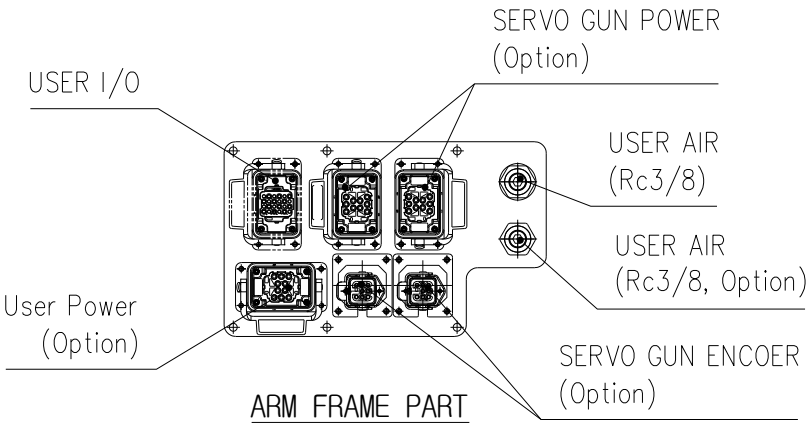


Figure 2.10 Wiring and Piping Diagrams for Applications

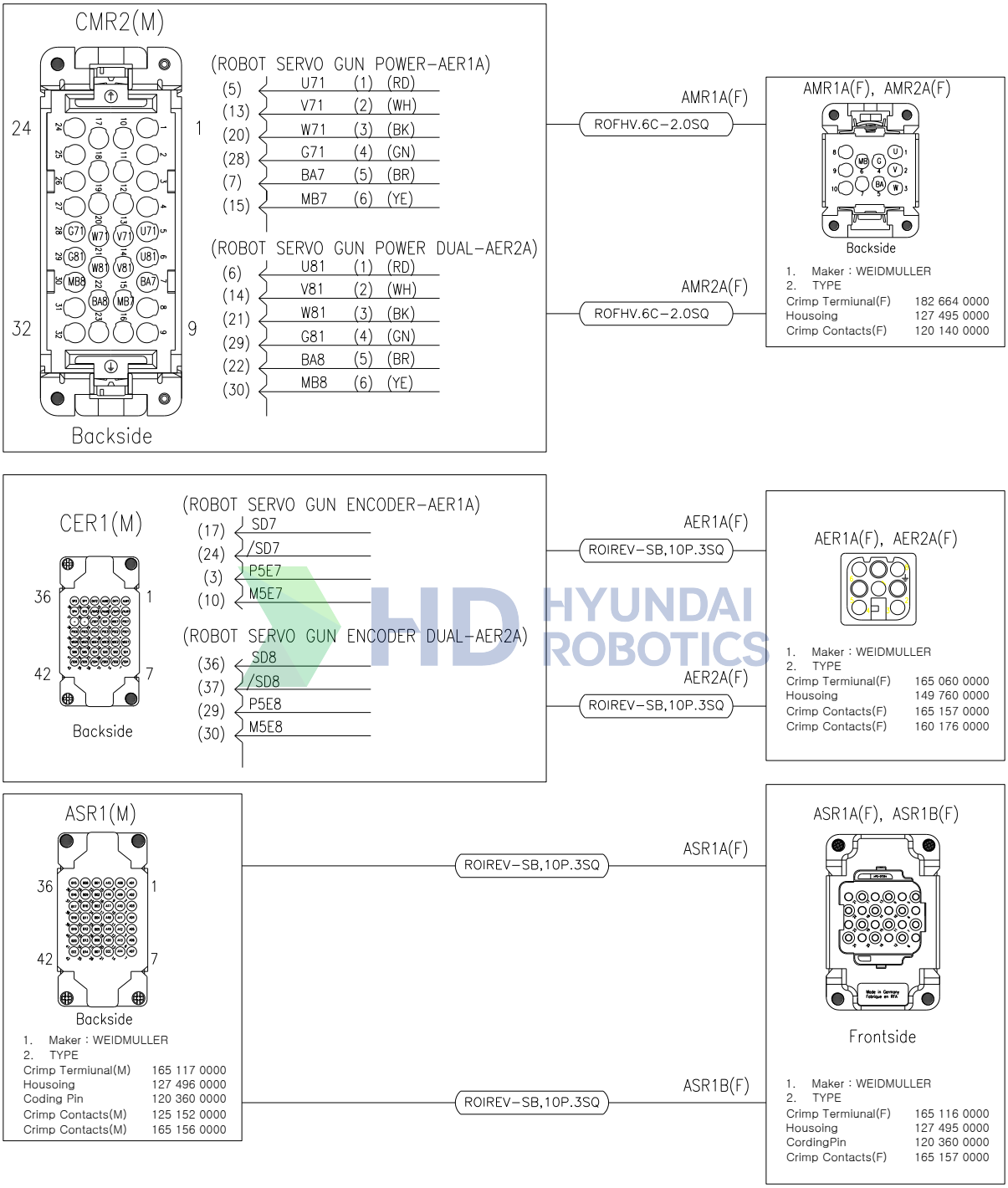


Figure 2.11 Details of Application Connectors

2.9. Limitation of the Operation Range

When installing the robot, you need to consider that its operation range can be freely adjusted within the entire operation area.

It is useful to limit the operation range in the following circumstances.

- When required to limit the operation area during the operation of the robot.
- When collision with a peripheral device may occur
- When the length of the application cable or hose is limited

There are three ways to keep the robot from moving out of its operation area, and they are as follows.

- Software limit (applicable to all axes)
- Limit switch (for axes 1 to 3: Optional)
- Mechanical stopper (for axes 1 to 3)

[Caution]
A mechanical stopper is a physical device. The robot should not be allowed to move beyond mechanical stoppers. The mechanical stoppers for axes 1-3 and 5 are fixed. For axes 4 and 6, only software limits are applied.

Mechanical stoppers will be deformed even when collided upon once, and their strength cannot be guaranteed. Therefore, the impacted mechanical stopper must be replaced.

2.9.1. Axis 1 (axis S)

By adding one mechanical stopper, you can limit the operation range (by 30 °) for axis 1. If the stopper block and stopper of axis 1 are deformed by severe impact, they must be replaced.

3

Precautions for Handling

3.1. Names of Individual Parts

The names of individual parts of the manipulator are as follows.

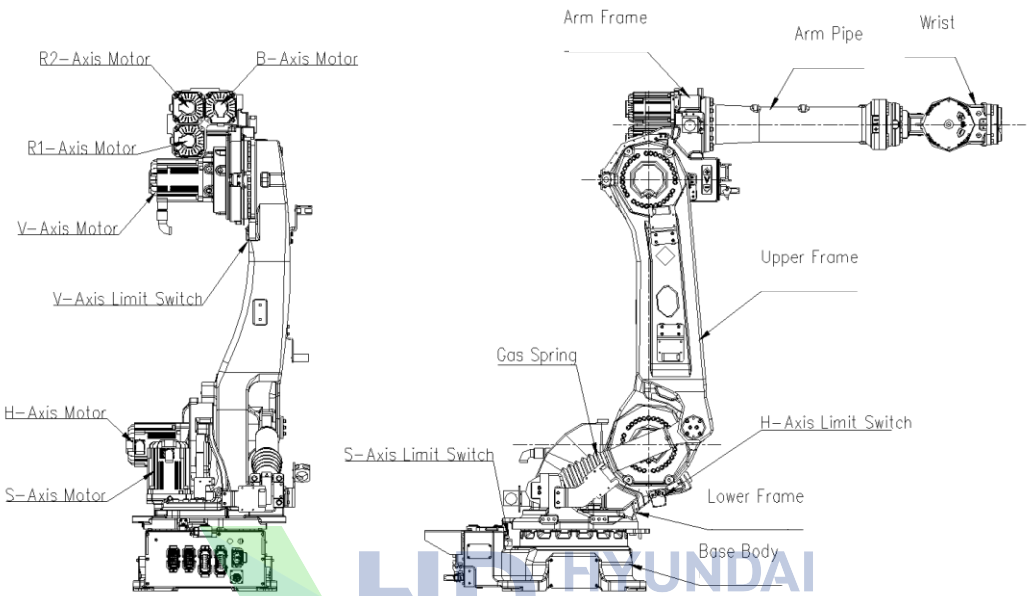


Figure 3.1 Names of Individual Part of the Manipulator

The limit switches for the basic three axes are optional.

3.2. Locations of the Safety Nameplates

To prevent safety accidents, safety nameplates are attached to the manipulator as shown in the figure below. Do not replace or remove them unnecessarily.

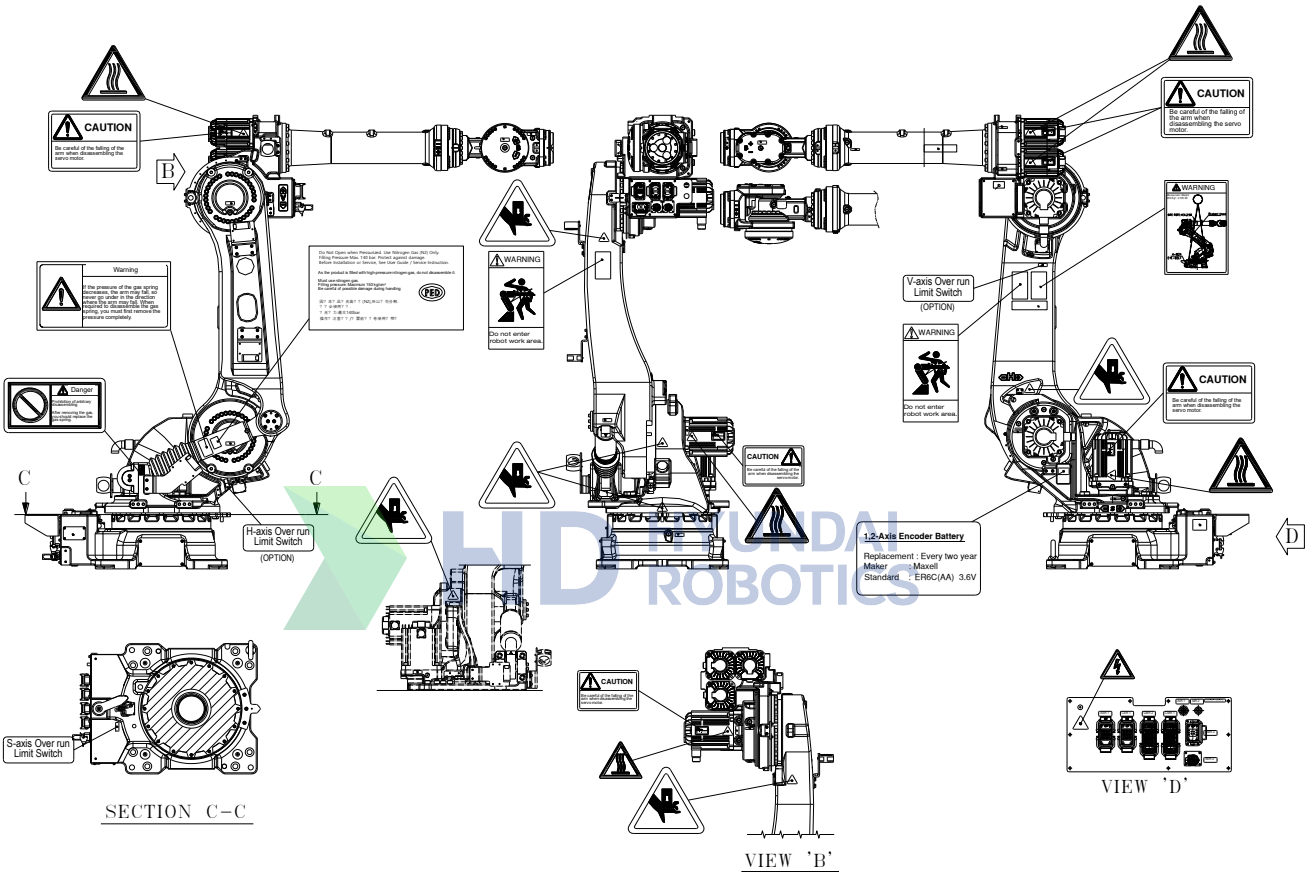
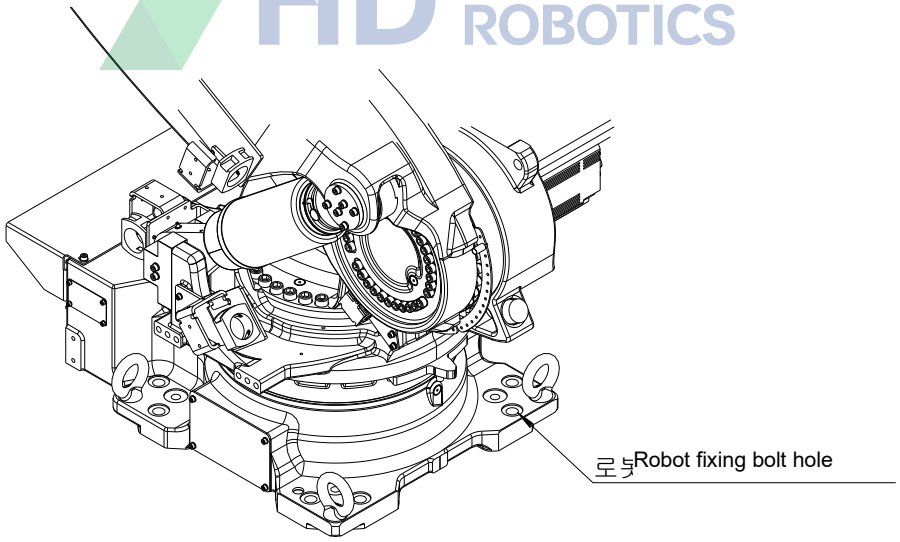


Figure 3.2 Locations of the Safety Nameplates

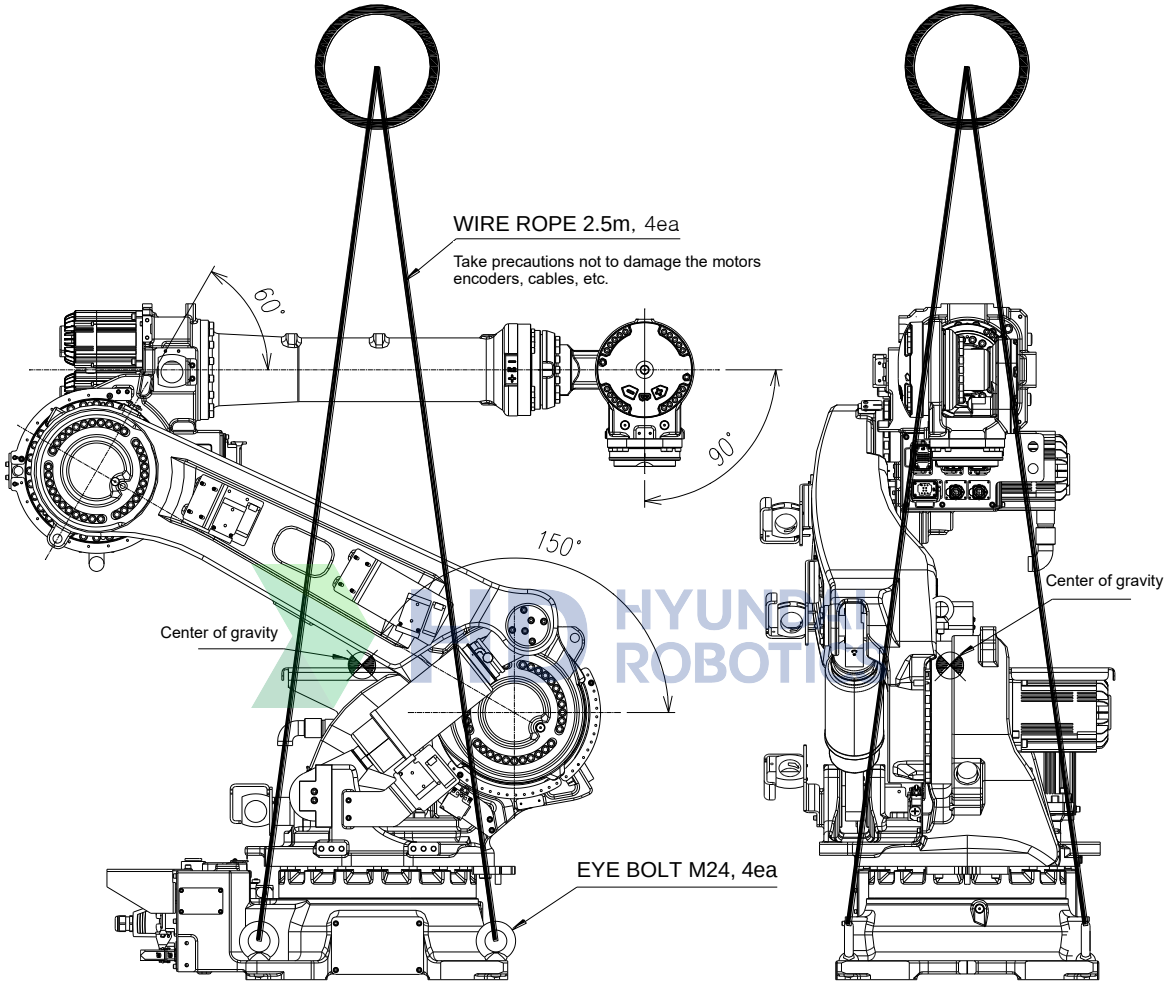
3.3. How to Transport

The robot can be transported using a crane and forklift. When moving the robot, put the robot into a posture suitable for each transport situation as shown in the figure below, and transport it using eyebolts and designated transportation equipment.

- You need to move or unload the robot slowly and very carefully.
- When unloading the robot onto a floor, be careful not to cause a strong collision between the bottom installation surface of the robot and the floor surface.
- Never transport the robot by means other than the specified transport 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 you disassemble or assemble the transport equipment (forklift brackets), the manipulator will slide. Fix the robot with bolts using the robot fixing bolt holes to prevent the robot from falling over.



3.3.1. Using a 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 a Crane

The following instructions for lifting the robot are valid for the robots in factory condition. Adding additional equipment to the manipulator will change the center of gravity and make lifting difficult.

- Never walk under the manipulator,
- Put the robot into the posture as shown in the figure.
- Install four M24 eyebolts to the base body.
- Connect the wire rope (four units) to the eye bolt (four units)
- Minimum crane capacity: 2.5 tons. Minimum rope capacity: 1 ton/piece
- Attach a protective hose (50 cm) to prevent the manipulator from being damaged.
- Follow the safety regulations when lifting the robot.
- Fix the ropes while being careful not to damage the motors, connectors, and cables of the robot.
- Manipulator weight:

Model	HS160L	HS180	HS220
Weight (kg)	985	955	955

3.3.2. Using a Forklift

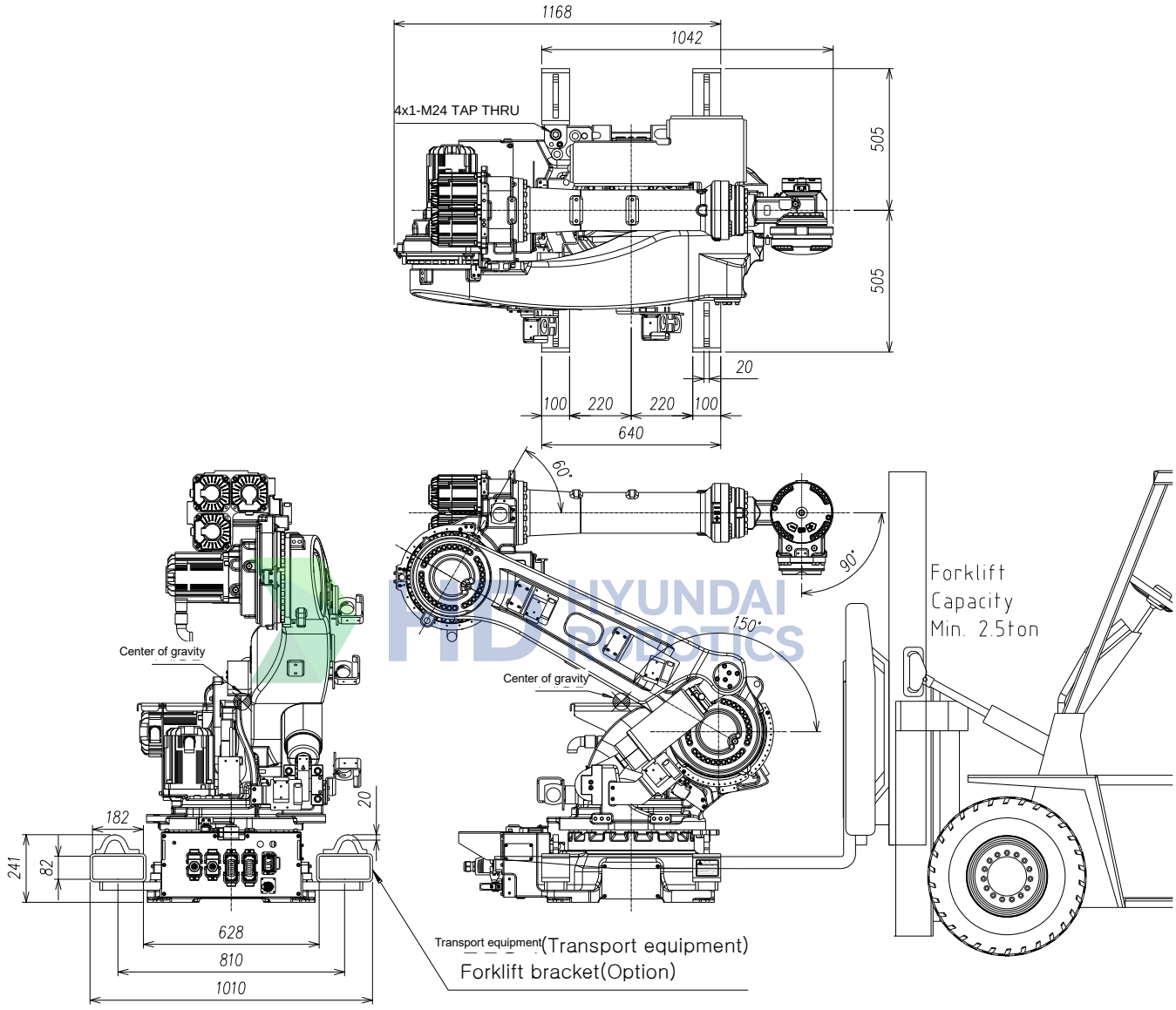
A forklift can be used to transport the manipulator.

For safety, observe the following procedures.

- Put the robot into the basic posture of each model by referring to the figure.
- 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.

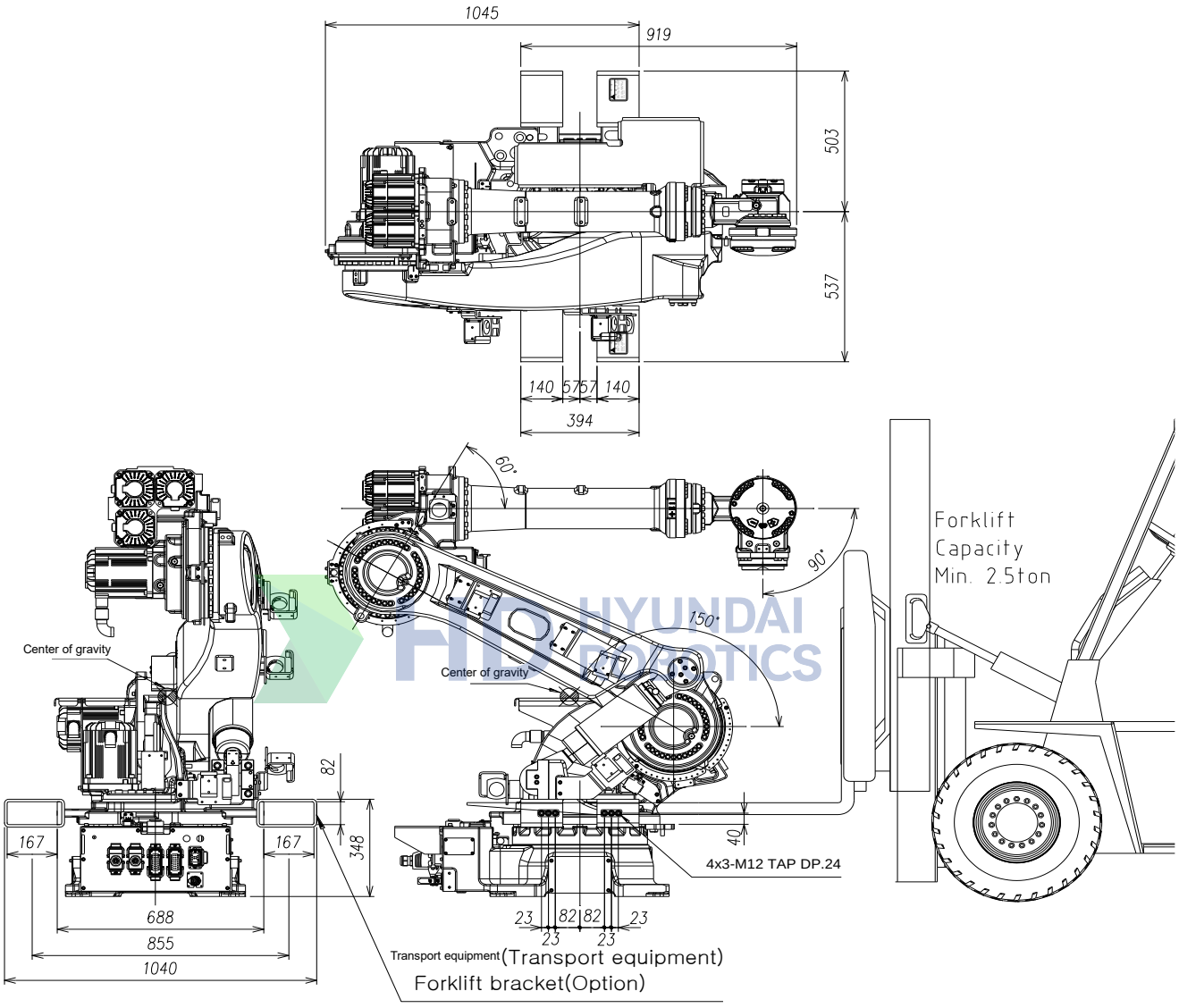
Cautions

- Do not lean against the manipulator while transporting it.
- Check to make sure that the manipulator does not collide with the floor while being loaded and unloaded.
- Observe the safety regulations while working with the forklift.
- 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 a Forklift (base body type)



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

Figure 3.5 How to Transport: Using a Forklift (lower frame type)

3.4. Storing the Robot

When storing the robot instead of installing it, put it into the posture as shown in [Figure 3.3.]

[Caution]
If the robot is in a different posture, it may fall over. When storing it for a long period of time, take safety measures against the risk of falling over.

3.5. Installation Methods

Caution:
Must read the safety regulations or related instructions carefully before unpacking and installing the robot. When necessary to use the robot in an environment other than the specified working conditions, please contact the service center.

Warning:
Installation must be performed by an installation expert, and the relevant regulations of the concerned country or region should be observed.
When unpacking the robot, check whether it is damaged during transport or while being unpacked. In addition, because the installation methods and foundation for the manipulator are very important in maintaining the functions of the robot, you should strictly observe the following items.

3.5.1. Working Conditions

(1) Ambient temperature should be 0℃–45℃.
(2) Ambient humidity should be 20% RH–85% RH, without condensation.
(3) There should be a low amount of dust, oil, moisture, etc.
(4) There should be no flammable, corrosive liquids and gases.
(5) There should be no large impact or vibration.
(6) There should be no source of a large electric noise nearby.
(7) If you do not install the robot right away, store it in a dry place with an ambient temperature of -15℃–40℃.

3.5.2. Installing the Manipulator

The rigidity of the foundation floor where the robot is to be installed should be able to minimize the dynamic influence of the robot, so the concrete thickness of the floor surface should be 300 mm or more. When installing the robot, you should perform maintenance works for irregularities and cracks on the concrete floor and then fix the mounting plate using the M20 chemical anchor. Also, if the thickness of the concrete floor is less than 300 mm, a separate foundation work is required, so please review this in advance before the construction work.
Position the manipulator on the mounting plate and then fasten it firmly with eight M20 bolts.

- Bolt : M20*70 (strength grade: 12.9)
- Flat washer : T = 4 mm or more, inner diameter (ID) = 24, and hardness = HrC 35 or more
- Tightening torque: 5700 kgfcm

3.5.3. Installation Surface Precision

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.

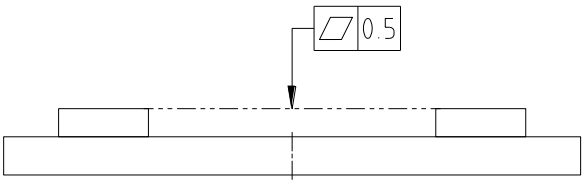


Figure 3.6 Installation Surface Precision

3.5.4. Installation Surface Dimensions

For attaching the manipulator, fix the bottom surface of the swivel base (base body.)
For the dimensions, refer to the figure below.

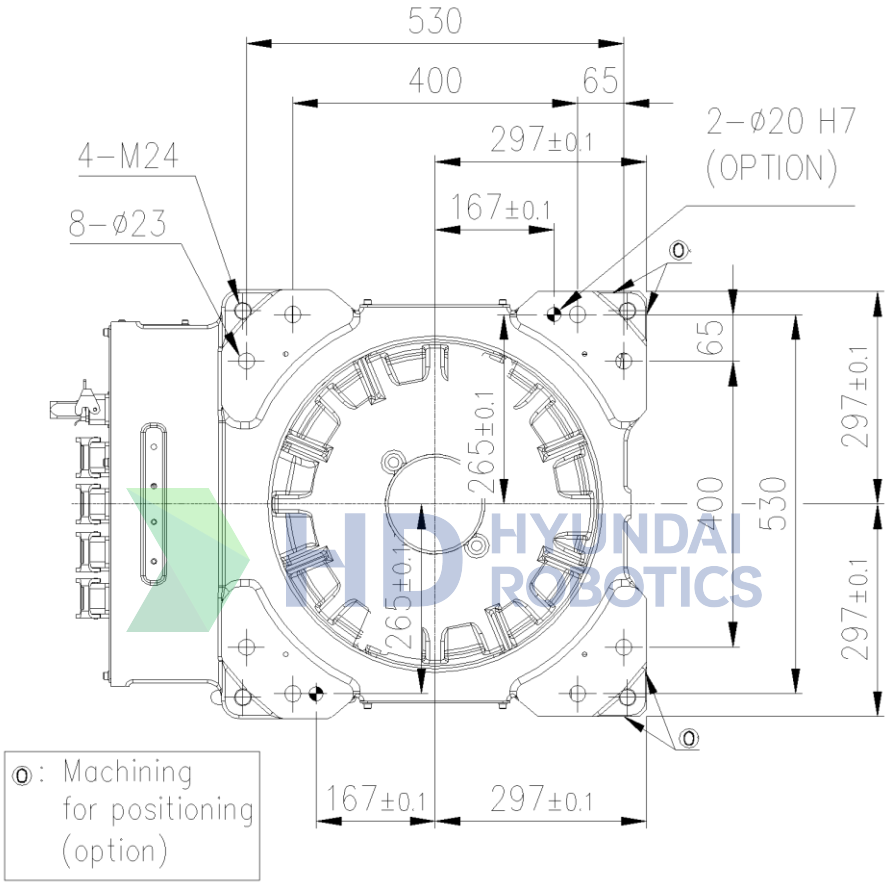


Figure 3.7 Robot Installation Surface Dimensions

3.5.5. Connecting the Robot Cables

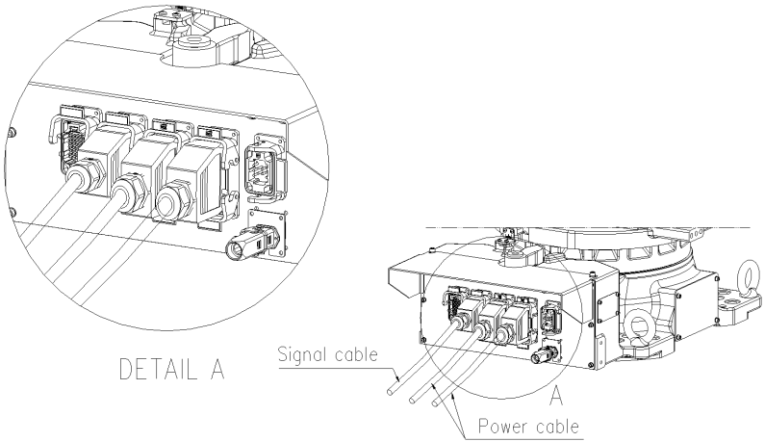


Figure 3.8 Connecting the Robot Cables

The robot is connected to the controller through the power and signal cables. Connect these cables to the connectors on the back of the robot base body. Also connect the grounding wire.
For connection of the pneumatic and optional cables, refer to "2.8 Wiring and Piping Diagrams for Applications."

Must turn off the power of the controller when connection the cables.

3.5.6. Time and Distance for Emergency Stop

While a standard load is amount, if an emergency stop is performed during operation at maximum speed, the response time and distance for emergency stop for each axis (S-axis, H-axis, V-axis) are measured as follows.

- HS180/HS220
  Maximum time : 0.615 seconds
  Maximum moving distance : 43.70 Inch / 111 cm

- HS160L
  Maximum time : 0.435 seconds
  Maximum moving distance : 30.27 Inch / 76.9 cm

3.5.7. Connecting a Load

In the case of a load to be attached to the tip of the wrist axis of the robot, you should limit the load attachment method and form to prevent abrasion from being caused by contact with the R1 axis part that performs relative motions. If these limits are not properly applied, the resulting contact may damage the seal and cause oil leakage.

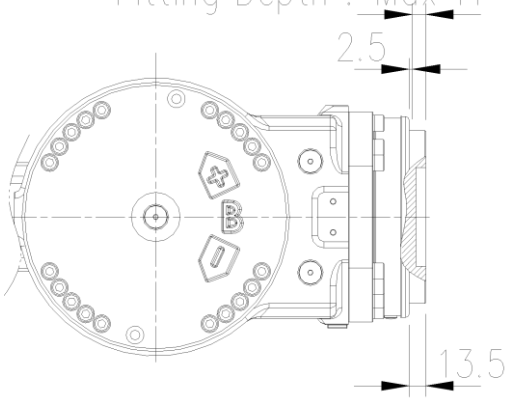


Figure 3.9 Form of Attachment to the Tip of the Robot

3.6. Allowable Loade for the Wrist Axis

3.6.1. Calculating the Allowable Load Torque

The load to be attached to the tip of the wrist axis of the robot is regulated by the allowable weight, allowable load torque, and allowable moment of inertia. The direction of the coordinate system to be used for calculating the load torque and moment of inertia is the same as that of the robot base coordinate system. The review of the R2 axis will be performed in the same way as done for the B axis.

- Step 1
  Calculate the position of the center of gravity at the center of rotation of the B axis (L_X, L_Y, L_Z)
  L_x: Position of the center of gravity in the direction of X axis
  L_y: Position of the center of gravity in the direction of Y axis
  L_z: Position of the center of gravity in the direction of Z axis

- Step 2
  Calculate the distance from the B and R1 axes to the center of gravity respectively.
  $$L_B = \sqrt{L_X{}^2 + L_Z{}^2} \quad L_{R1} = \sqrt{L_Y{}^2 + L_Z{}^2}$$
  L_B: Distance from the center of rotation of B axis to the center of gravity
  L_{R1}: Distance from the center of rotation of the R1 axis to the center of gravity

- Step 3
  Calculate the load torque based on the calculated distance.
  $$T_B = MgL_B \qquad T_{R1} = MgL_{R1}$$
  T_B: Load torque at the center of rotation of B axis
  T_{R1}: Load torque at the center of rotation of the R1 axis
  M: Load mass
  g: Gravitational acceleration

- Step 4
  Check whether the load torque calculated in Step 3 is below the limit value based on the table of allowable load torques.

■ Note: If the load mass is similar to the mass indicated on the torque curve below, the verification of the load torque can be substituted by checking whether the distance calculated in Step 2 is distributed within the torque curve instead of going through Steps 3 and 4. If the calculated distance is within the torque curve, the calculated load torque is smaller than the allowable load torque, and if it is located outside the torque curve, the calculated load torque is larger than the allowable load torque.

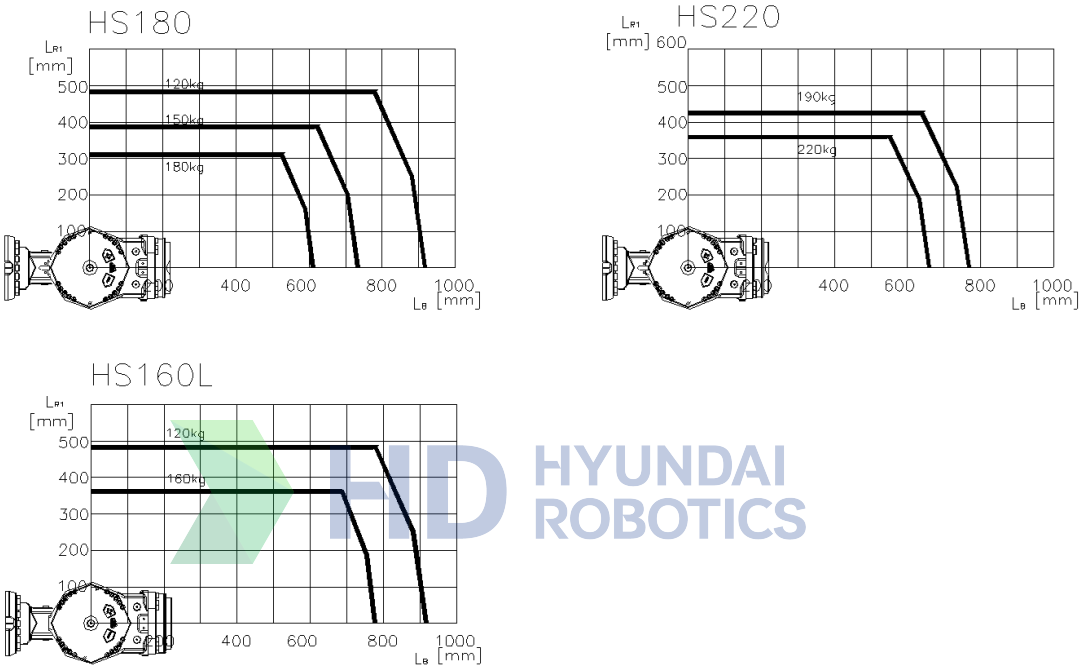


Figure 3.10 Wrist Axis Torque Curve

Allowable Load Torque

Table 3-1 Allowable Load Torque

Payload	Allowable Load Torque		
	Rotation of the R2 axis	Rotation of the B axis	Rotation of the R1 axis
HS160L,HS180	Within 1079 N·m (110 kgf·m)		Within 566 N·m (58 kgf·m)
HS220	Within 1422 N·m (145kgf·m)		Within 770 N·m (79 kgf·m)

3.6.2. Calculating the Allowable Moment of Inertia

By referring to [Table 3-2], use the load so that it does not exceed the allowable conditions.

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

- Step 2
  Based on the table of allowable moments of inertia, check whether the value of the moment of inertia is below the limit value.

Allowable Moment of Inertia

Table 3-2 Allowable Moment of Inertia

Payload	Allowable Moment of Inertia		
	Rotation of the R2 axis	Rotation of the B axis	Rotation of the R1 axis
HS160L,HS180	106 kg·m² (10.8kgf·m·s²)		56 kg·m² (5.7kgf·m·s²)
HS220	152 kg·m² (15.5kgf·m·s²)		86 kg·m² (8.8kgf·m·s²)

3.6.3. Examples of Calculation of the Allowable Torque and Allowable Moment of Inertia (HS180)

(1) Case #1 Simple two-dimensional model

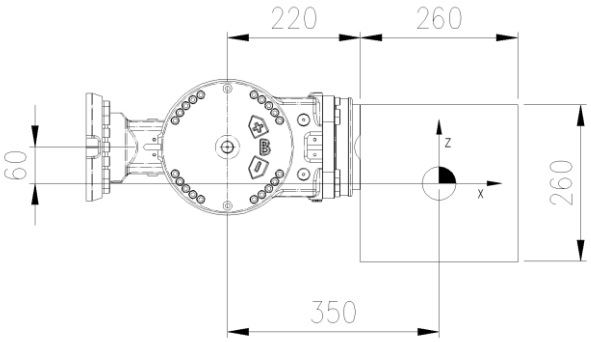


Figure 3.11 Two-Dimensional Load Model

M – Load weight
J_{xx} - Moment of inertia in the direction of the X axis at the center of the gravity of the load
J_{yy} - Moment of inertia in the direction of the Y axis at the center of the gravity of the load
J_{zz} - Moment of inertia in the direction of the Z axis at the center of the gravity of the load
J_{a4} - Moment of inertia at the center of rotation of the R2 axis
J_{a5} - Moment of inertia at the center of rotation of the B axis
J_{a6} - Moment of inertia at the center of rotation of the R1 axis

☞ Load condition: Stainless Steel (with mass of 138.15 kg) with a width of 260 mm and a thickness of 260 mm

① Weight limit
Load weight: 138.15 ≤ 180 kg

② Limit of the allowable torque
The position of the center of gravity with respect to B axis: L_X = 350 mm, L_Y = 0 mm and L_Z = -60 mm
Each distance from B axis and R1 axis to the center of gravity can be calculated respectively as follows.
Distance with respect to the B axis $L_B = \sqrt{0.35^2 + 0.06^2} = 0.355$ m
Distance with respect to the R1 axis $L_{R1} = 0.06$ m
Load torque of the B axis $T_B = MgL_B = 49.04$ kgfm ≤ 110 kgfm
Load torque of the R1 axis $T_{R1} = MgL_{R1} = 8.29$ kgfm ≤ 58 kgfm

③ Limit of the allowable moment of inertia
The moments of inertia of the load at the center of gravity: J_{xx}= 1.56kgm^2, J_{yy}= 1.56 kgm^2, and J_{zz}= 1.56 kgm^2
Moment of inertia of the B axis (Ja5)
$J_{a5} = ML_B^2 + J_{yy} = 138.15 \times 0.355^2 + 1.56 = 18.97 \leq 106$ kgm^2
Moment of inertia of the R1 axis (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 all conditions of weight, torque, and moment of inertia satisfy the conditions of limit.

(2) Case #2 Complex three-dimensional model

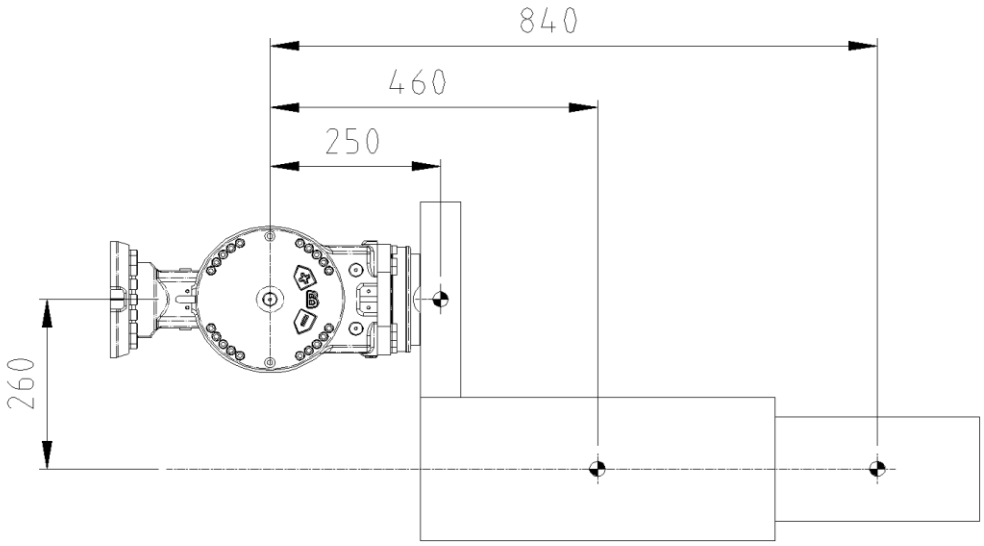


Figure 3.12 Two-Dimensional Shape of a Three-Dimensional Load Model

Combination of aluminum block shapes
(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 - Load weight of i block
L_{Xi} - Position of the center of gravity of i block in the direction of X axis
L_{Yi} - Position of the center of gravity of i block in the direction of Y axis
L_{Zi} - Position of the center of gravity of i block in the direction of Z axis

① Weight limit
Load weight: 176.3 ≤ 180 kg

② Limit of the allowable torque

The position of the center of gravity of all loads at the center of rotation of the B axis can be calculated 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 (Y 축 대칭이므로)

$$L_z = \frac{\sum_i m_i L_{zi}}{\sum_i m_i} = \frac{14.6 \times 0 + 125.4 \times 260 + 36.3 \times 260}{176,3} = 238.47 \text{ mm}$$

Position of the center of gravity of all blocks with respect to B axis L_x = 520.85mm, L_y = 0mm, L_z = -238.47mm

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

Load torque of the B axis $T_B = MgL_B = 101.02$ kgfm ≤ 110 kgfm
Load torque of the R1 axis $T_{R1} = MgL_{R1} = 41.96$ kgfm ≤ 58 kgfm

x1 y1 z1 – Lengths of m1 block in the x, y, and z directions respectively
x2 y2 z2 – Lengths of m2 block in the x, y, and z directions respectively
x3 y3 z3 – Lengths of m3 block in the x, y, and z directions respectively

L_{X1}, L_{Y1}, L_{Z1} - Position of the center of gravity of m1 block at the center of rotation of the B axis
L_{X2}, L_{Y2}, L_{Z2} - Position of the center of gravity of m2 block at the center of rotation of the B axis
L_{X3}, L_{Y3}, L_{Z3} - Position of the center of gravity of m3 block at the center of rotation of the B axis

J_{xx1}, J_{yy1}, J_{zz1} – Moment of inertia of each of x, y, and z axes at the center of gravity of m1 block.
J_{xx2}, J_{yy2}, J_{zz2} – Moment of inertia of each of x, y, and z axes at the center of gravity of m2 block.
J_{xx3}, J_{yy3}, J_{zz3} – Moment of inertia of each of x, y, and z axes at the center of gravity of m3 block.

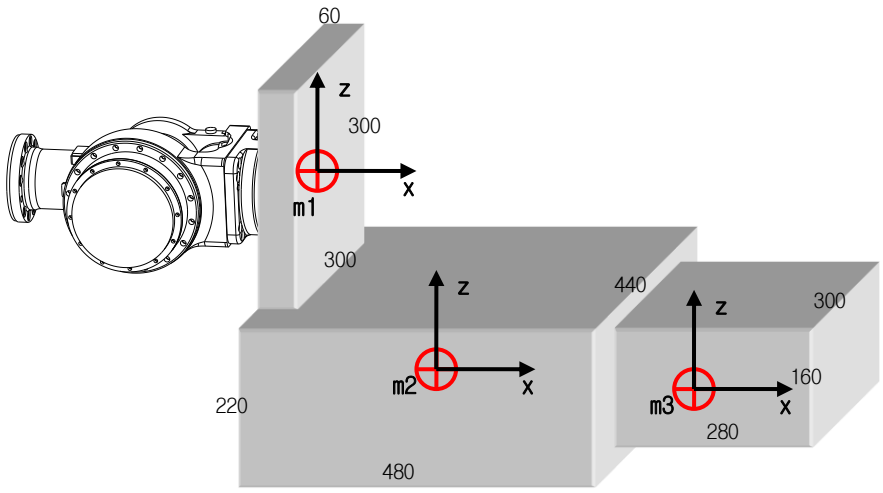


Figure 3.13 Three-Dimensional Shape of a Three-Dimensional Load Model

③ Limit of the allowable moment of inertia

Table 3-3 Moment of Inertia at the Center of Gravity of Each Block

Block weight (kg)	Center of gravity (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)	(0.48, 0, -0.26)	2.530 kgm^2	2.915 kgm^2	4.433 kgm^2
m_3 (36.3)	(0.89, 0, -0.26)	0.350 kgm^2	0.314 kgm^2	0.509 kgm^2

Moment of inertia of the B axis (J_{a5})

$$J_{a5} = \sum_i [m_i(L_{xi}^2 + L_{zi}^2) + J_{yyi}]$$

$$= [14.6 \times (0.25^2) + 0{,}114] + [125.4 \times (0.46^2 + 0.26^2) + 2.915] + [36.3 \times (0{,}85^2 + 0.26^2) + 0.314] = 67.95 \leq 106 \text{ kg}m^2$$

Moment of inertia of the R1 axis (J_{a6})

$$J_{a6} = \sum_i [m_i(L_{yi}^2 + L_{zi}^2) + J_{xxi}]$$

$$= [14.6 \times (0^2) + 0{,}219] + [125.4 \times (0.26^2) + 2.530] + [36.3 \times (0.26^2) + 0.350] = 14.03 \leq 56 \text{ kg}m^2$$

④ Conclusion

It is safe because all conditions of weight, torque, and moment of inertia satisfy the conditions of limit.

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4 Inspection

This chapter describes regular inspection, disassembly, and adjustment necessary to maintain the performance of the robot for a long time.

4.1. Inspection Plan

Inspection is absolutely necessary to maintain high performance when operating the robot for a long period of time.
Inspection consists of daily inspections and periodic inspections. The basic inspection cycles are indicated in [Table 4-1]. The person in charge of inspection must conduct inspections according to the inspection cycles.
Should perform overhauling every 35,000 operation hours.

As the inspection cycles were reviewed for the spot welding, it is recommended to perform inspections at about half the cycles shown in [Table 4-1] for high-accuracy operations such as handling. If it is difficult to understand the inspection and adjustment methods, contact our Aftersales Service Center (Customer Support Department.)

Table 4-1 **Inspection Plan**

Daily inspection	**Daily**	Manipulator, motors, reducers and gas springs.
Periodic inspections	**Every three months**	Wirings, bolts and reducers
	Every six months	Gas springs and gas spring bearings
	Every one year	Limit switches/dogs, brakes

4.2. Inspection Items and Cycles

Table 4-2 Inspection Items and Cycles

No.	Inspection cycle				Inspection item	Inspection method	Reference	Remarks
	Daily	Every three months	Every six months	Every one year				
Common for the manipulator and each axis								
1	○				Cleaning of the manipulator	Check for impurities with eyes		
2		○			Inspection of the wirings	Check the cables for any damage with eyes. Cable fixing bracket fastening bolts. Check the paint markings with eyes. Check for any damage to the cable cover with eyes.		
3		○			Main bolts	Check the paint markings with eyes.		
4				○	Limit switches /dogs	Check the on and off functions of the limit switches.	It should be checked that the emergency stop lamp is turned on when the limit switch is turned on.	
5	○				Motors	Check for any abnormal heating. Check for any abnormal sound.		
6				○	Brakes	Check whether the brake works when the brake release switch is turned on and off. Note) When the brake release switch is turned on, the arm or operating axis will fall, so turn it off within one second when checking.	The arm or end effector should not fall when the brake release switch is turned off.	
S, H and V axes								
7	○				Reducers	Check for any abnormal sound. Check for any vibration.		
8	○		○		Gas springs Pressure	Check the pressure.	125 ~ 140bar	
9			○		Gas springs Bearings	Check the bearing part for any overheating, impurities or vibration.	Grease at the bearing part should be maintained properly.	
R2, B, and R1 axes								
10		○			Reducers	Check for any abnormal sound. Check for any vibration.		

No.	Inspection cycle				Inspection item	Inspection method	Reference	Remarks
	Daily	Every three months	Every six months	Every one year				
11		○			End effector fastening bolts	Check the paint markings with eyes.		
12		○			Clearance	Check for any clearance by rotating each axis in the right and reverse directions.	There should be no clearance felt with hands.	

- If the robot is used in adverse conditions (for example, spot welding, grinding, etc.), you need to shorten the inspection cycles 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 pressure of the gas spring 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 pressure of the gas spring.

4.3. Inspection of Main External Bolts

The recommended bolt torques are shown in the figure below.
Must tighten the bolts with appropriate torques by using a torque wrench and then mark them with paint.
Please use 12.9T (strength grade) bolts.

Table 4-3 Main Bolts to be Inspected

No.	Bolts to be Inspected	No.	Bolts to be Inspected
1	H axis reducer attachment bolt	7	Arm pipe attachment bolt
2	H axis attachment bolt	8	R2 axis attachment bolt
3	V axis attachment bolt	9	Grip assembly attachment bolt
4	V axis attachment bolt	10	B axis attachment bolt
5	Gas top plate attachment bolt	11	R1 axis reducer attachment bolt
6	Contraction motor attachment bolt	12	End effector attachment bolt

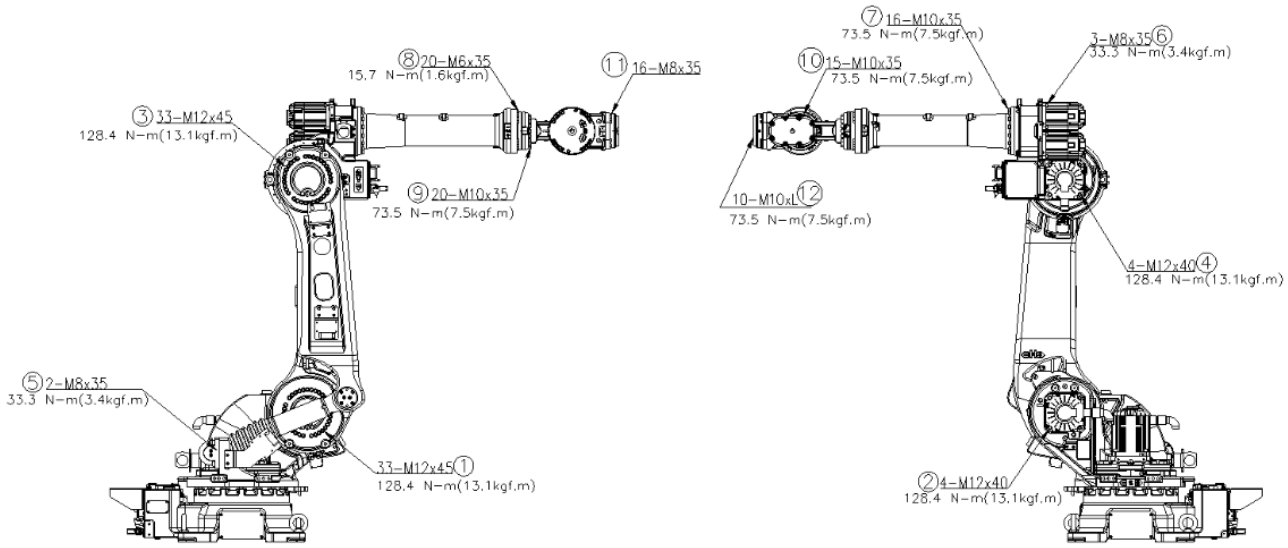

Figure 4.1 Main Bolts to be Inspected

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5 Maintenance

5.1. Injecting Grease after Replacing Grease or Replacing the Reducer

Caution

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

(1) Must wear protective glasses before injecting or inspecting the grease.

(2) Must remove the outlet plug before injecting the grease.

(3) When the plug is loosened, the grease and plug may be abruptly discharged. Block the outlet with a thick cloth to prevent the discharged object from damaging parts of your body, such as the face, and keep a safe distance (Do not look into the grease outlet.)

(4) If possible, do not use a compressed air pump powered by factory-supplied air, and limit the grease injection pressure to 1.5 bar (1.5 kgf/cm2, 0.15 MPA) or less.

(5) Use only the specified grease. Otherwise, the reducer may be damaged or other problems may be caused.

(6) After injecting the grease, check whether there is any leakage from the grease outlet and whether there is any pressure at the inlet. Remove the residual pressure according to the method suggested for each axis, and then connect the plug.

(7) To prevent accidents, wipe off any spilled grease on the robot body or floor.

(8) If the robot is used at an ambient temperature of 35℃ or higher, the grease replenishment and replacement cycles should be shortened by 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 1 to 2 days. Abnormal sound caused by grease will disappear

(11) If grease with a different specification is injected into a reducer part greased already, an abnormal sound may occur from the reducer part. Therefore, do not mix 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 old grease is replaced with the new grease of the

same designated specification as the old grease.

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

■ **Grease replacement cycle**

Grease replacement cycle

- ✓ **S-axis reducer and arm frame gear box : Every 24,000 hours**
- ✓ **Other reducers : Every 12,000 hours**
- ✓ **Gas spring bearing : Every six months (every three months in adverse situations)**

■ **Measures for and Causes of Abnormal Grease Sound**

If an abnormal sound is generated in the reducer part despite using the specified grease, 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 min 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 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 of grease of different specifications

5.1.1. Grease Injection Amount for Each Axis

Axis	Amount of injection when replacing a reducer (A)				Amount of injection when replacing the grease (A)*80% or more			
	VIGO GREASE RE0		EUREKA 114 No.0		VIGO GREASE RE0		EUREKA 114 No.0	
	cc	g	cc	g	cc	g	cc	g
S	4,222	3,800	4,222	3,547	3,378	3,040	3,378	2,838
H	2,889	2,600	2,889	2,427	2,311	2,080	2,311	1,942
V	2,778	2,500	2,778	2,333	2,222	2,000	2,222	1,866
R2	1,111	1,000	1,111	933	889	800	889	746
B	1,500	1,350	1,500	1,260	1,200	1,080	1,200	1,008
R1	222	200	222	187	178	160	178	150

5.1.2. Amount of Injection for the Arm Frame Gear Box

Classification	Amount of injection when replacing the grease		Remarks
	GADUS S2 V46 2		
	cc	g	
GEAR BOX	500	450	Inject a specified amount of grease as much as the amount of the discharged grease.

5.1.3. Plug Size for Each Axis

Axis	Inlet	Outlet
S	G1/4	G1/4
H	G1/4	G1/4
V	G1/4	G1/4
R2	G1/4	G1/4
B	G1/4	G1/4
R1	M5	G1/4
GEAR BOX	G1/4	G1/4

5.1.4. Sequence for Replacing the Grease

(1) Move the robot into a posture that allows grease injection to be performed without any interference with surrounding facilities.
(2) Move the robot into a posture so that the positions of the grease inlet and outlet are as far apart as possible.
(3) Turn off the power of the controller.

(4) Remove the plugs from the grease inlet and outlet.
(5) When grease is injected while the outlet plug is not removed, the internal pressure will rise and
the grease will be momentarily spurting out. Before injecting the grease, you must check whether the outlet plug is removed.
(6) Decrease the air pressure of the oil pump to the minimum pressure at which grease can be discharged.
(7) Attach a grease receiver such as vinyl with an opened entrance to the grease outlet to prevent contamination of the surrounding area.
(8) The entrance of the grease receiver must be kept opened to prevent the pressure inside the grease barrel from rising.
(9) Prepare the oil pump and grease receiver in a way that enables you to measure the amounts of injected grease and discharged grease.
(10) Inject the grease by connecting the injection hose to the inlet.
(11) Inject the grease until the color of the grease discharged through the grease outlet changes sufficiently to the color of the new grease.
(12) Compare the amounts of injected grease and discharged grease and then if grease is excessively injected, you should subtract the excess grease to make sure that the amount of the injected grease is the same as that of the discharged grease, by referring to the "Sequence for Subtracting the Residual Pressure" and the "Sequence for Discharging the Grease."

5.1.5. Sequence for Subtracting the Residual Pressure

(1) Move the robot into a posture to ensure that it has no interference with surrounding facilities when it is operating.
(2) Attach a grease receiver such as vinyl with an opened entrance to the grease outlet to prevent contamination of the surrounding area.
(3) Operate the robot in the following conditions within the range that will not cause interference with the surroundings.

Axis	Operation angle (axis 1/axis 2/axis 3)	Playback speed	Operation time
Axis 1–Axis 3	80° /90° /70° or above	50 %	Minimum 20 minutes
Axis 4–Axis 6	60° /120° /60° or above	50~100 %	Minimum 20 minutes
Arm gearbox	60° /120° /60° or above	50~100 %	Minimum 20 minutes

(4) Wipe the outlet with a cloth and assemble the plug back into place.
(5) Measure the discharged grease so that it can be included in the amount of discharged grease.

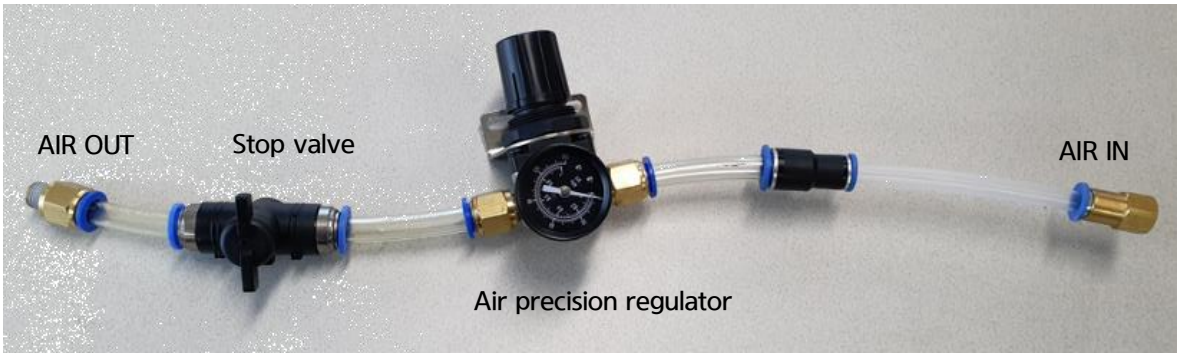
5.1.6. Sequence for Discharging the Grease

(1) Check the difference between the amount of the injected grease and the amount of the discharged grease, and then determine the amount of grease to be discharged.
(2) Move the robot into a posture to ensure that it has no interference with surrounding facilities when it is operating.
(3) Attach a grease receiver such as vinyl with an opened entrance to the grease inlet to prevent contamination of the surrounding area.
(4) Prepare a grease receiver with a size that takes into consideration the amount of grease to be discharged.
(5) Install an air precision regulator set adjusted to 0.025 Mpa to the grease outlet.
The air precision regulator set consists of an air hose, a stop valve, and male push-to-connect fittings. Before installing the set, you need to open and close the stop valve to ensure that the instructed pressure is not exceeded. After that, put the stop valve handle in the Stop state so that air is not supplied.
(6) When discharging grease, pay attention so that the pressure at the grease injection part does not exceed 0.025 Mpa.
(7) Check if the plug of the inlet where the grease will be discharged is removed
(8) Open the stop valve to allow the grease to be discharged by air pressure, and check the amount of the discharged grease.
(9) If the amount of the discharged grease is insufficient, rotate the robot slowly so that the grease can be easily discharged.
(10) When the discharging of the grease is completed, remove the grease receiver and regulator set.
(11) Remove the contaminated grease around the inlet and outlet with a clean cloth.
(12) Connect the plugs to the outlet and inlet.

Warning

If air is supplied at too high a pressure to the inside of the grease barrel, etc. of the gearbox where grease is injected, there is a risk of grease suddenly ejecting. It must be covered so that the grease being charged from the grease outlet can only be discharged to the grease receiver. When discharging grease, you should wear safety clothing such as protective glasses, a face shield, and protective clothing.

To ensure that the pressure inside the grease barrel does not exceed 0.025 Mpa, you should set the pressure of the regulator by increasing its pressure from 0 Mpa to 0.025 Mpa gradually before installing it to the grease barrel. After that, check whether the set pressure is appropriate by opening and closing the stop valve several times. and then install the regulator



5.1.7. The Inlet and Outlet of the Reducer of S Axis

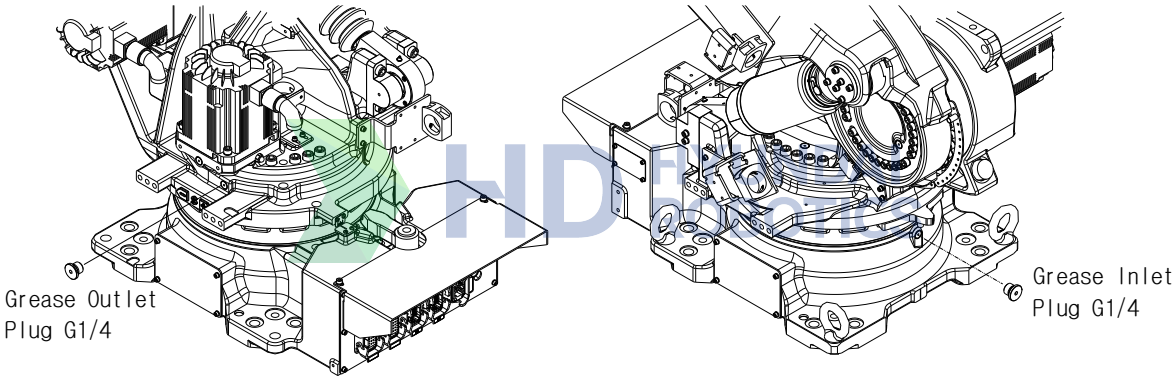


Figure 5.1 The Grease Inlet and Outlet of the Reducer of the S Axis

5.1.8. The Inlet and Outlet of the Reducer of the H Axis

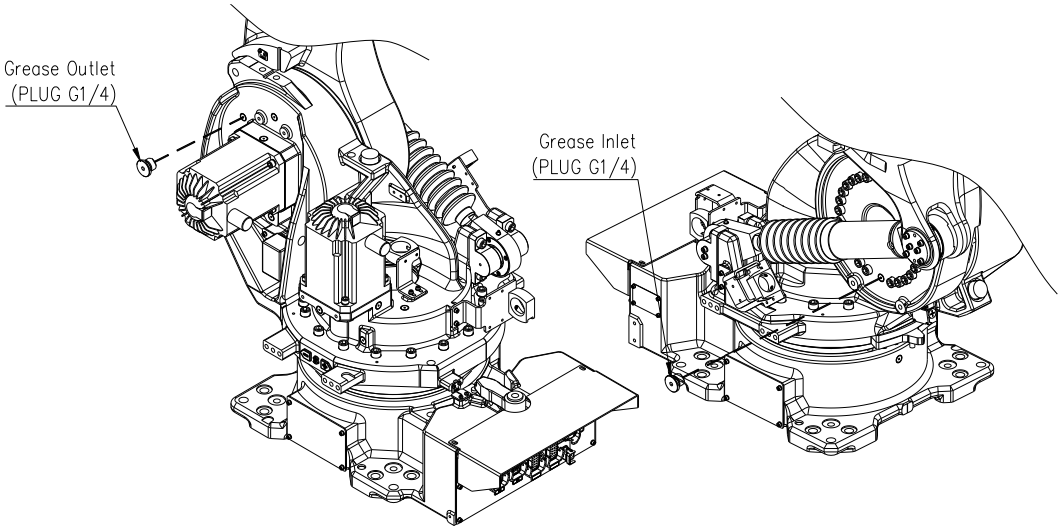


Figure 5.2 The Grease Inlet and Outlet of the Reducer of the H Axis

5.1.9. The Inlet and Outlet of the Reducer of the V Axis

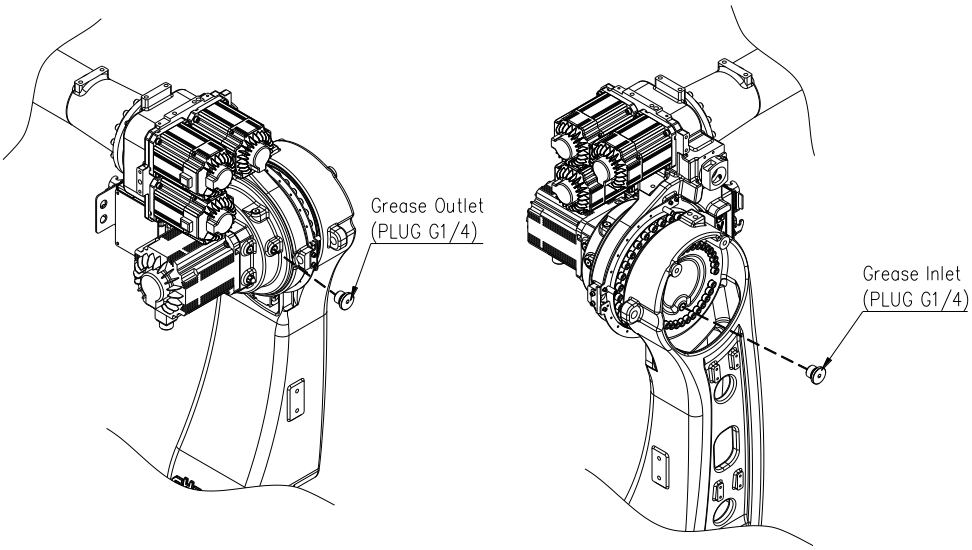


Figure 5.3 The Grease Inlet and Outlet of the Reducer of the V Axis

5.1.10. The Inlet and Outlet of the Reducer of the R2 axis

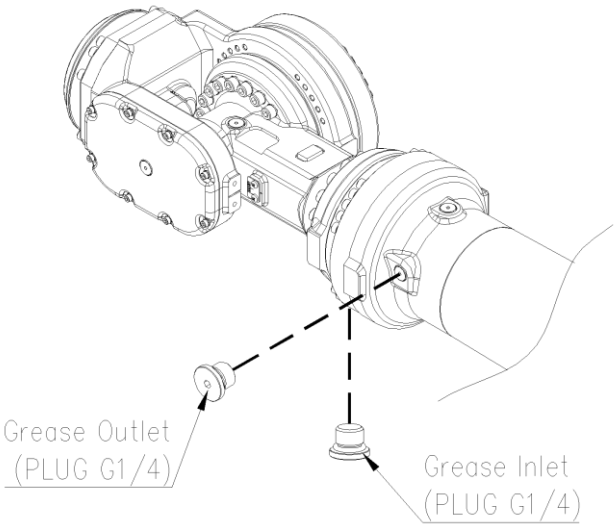


Figure 5.4 The Grease Inlet and Outlet of the Reducer of the R2 axis

5.1.11. The Inlet and Outlet of the Reducer of the B Axis

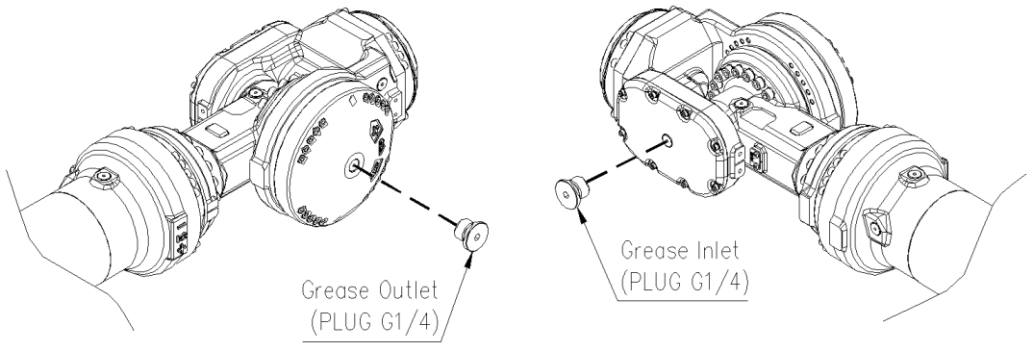


Figure 5.5 The Grease Inlet and Outlet of the Reducer of the B Axis

5.1.12. The Inlet and Outlet of the Reducer of the R1 axis

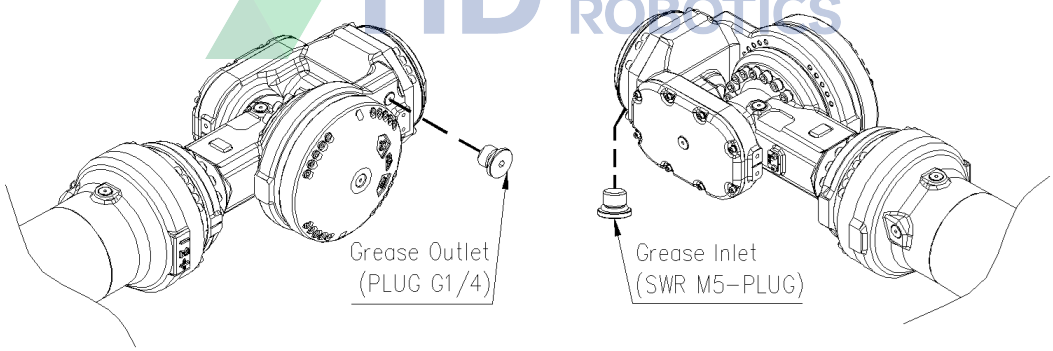


Figure 5.6 The Grease Inlet and Outlet of the Reducer of the R1 Axis

Caution

Do not inject grease excessively. Excessive grease may cause an increase in internal pressure, which may result in grease leakage and abnormal operation of the robot.

5.1.13. Inlet and Outlet of the Gearbox of the Arm Frame

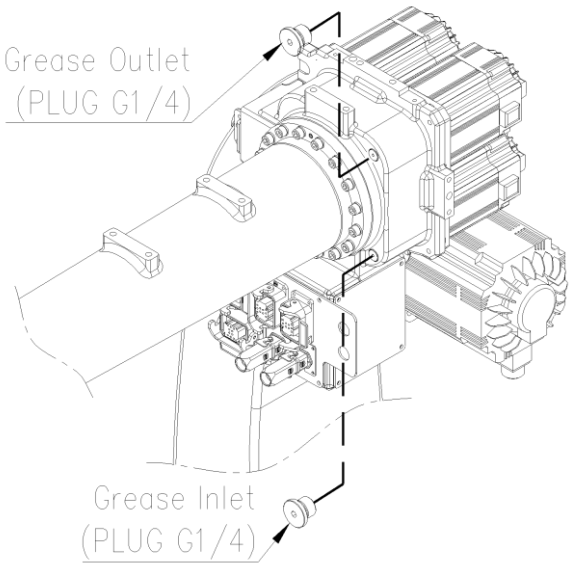


Figure 5.7 Grease Inlet and Outlet of the Arm Frame

5.1.14. Inlet of the Gas Spring Bearing

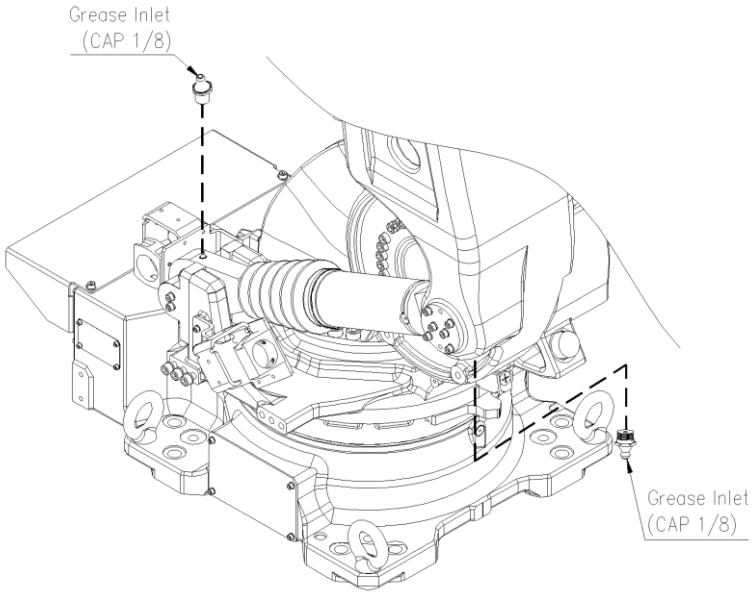


Figure 5.8 Inlet of the Gas Spring

(1) Open the nipple cap 1/8, and inject grease through the grease nipple A-PT1/8 using a grease gun (Air pressure 5~7 kg/cm^2, decompression not required.)

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

(2) Fill the grease through the grease nipple and inject it until the new grease comes out in 360° around the bearing through the gap between the NILOS-Ring and the bearing.

(3) Wipe the grease discharged to the outside because of excessive injection of grease with a cloth.

(4) Wipe the inlet with a cloth and assemble the nipple cap back into place.

5.2. Replacing the Battery

The position data of each axis is preserved with a backup battery. The battery must be replaced every two years. When replacing the battery, follow the procedures below.

(1) Press the emergency stop button while the power of the controller is turned on.

Caution

If you turn off the power and replace the battery, all current position data will be lost. As a result, it will be necessary to set the origin again.

(2) Remove the cover at the position of the battery of each axis.

(3) Remove the current battery.

(4) Place a new battery. Be careful about the direction of placing it.

- ✓ Battery specification: ER6V-T1 (AA) 3.6V
- ✓ Manufacturer: TOSHIBA

(5) Install the cover as it was.

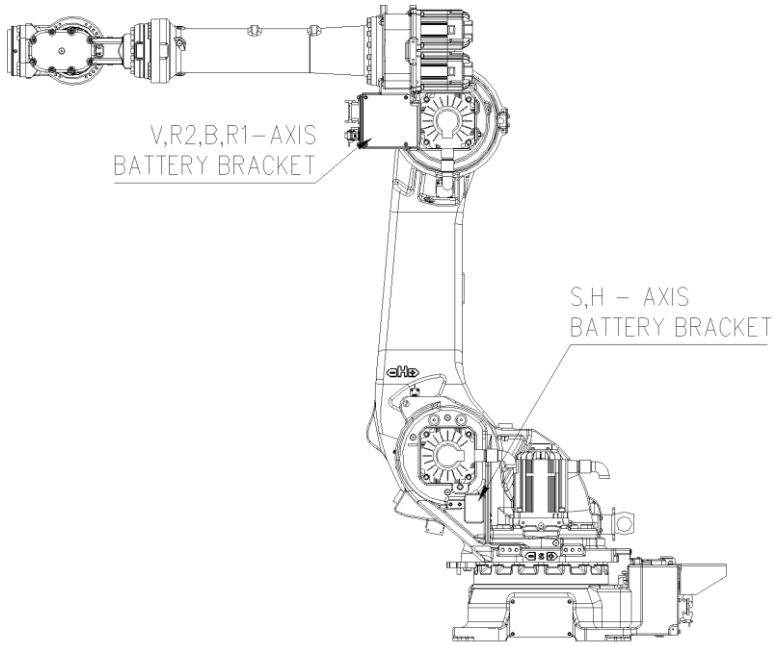


Figure 5.9 Position for Replacing the Battery

Caution

- ✓ Do not throw away the batteries. Dispose of them as industrial waste according to the laws and regulations of the concerned country.
- ✓ Do not recharge the battery. It may explode or get overheated.
- ✓ Do not use a battery other than the ones with designated specifications.
- ✓ Replace the current battery only with the specified ones.
- ✓ Do not short the negative and positive poles of the battery.
- ✓ Do not expose a battery to flame or high temperatures.

5.3. Replacing the Wirings inside the Manipulator

The replacement cycles for the wirings of the manipulator are influence by following items.

- Continuous operation
- Operation speed
- Ambient temperature

Perform the periodic inspection every three months and check the cables and cable protection springs for any damage. If damage is found, the damaged part should be replaced.

Replace the cables every 24,000 hours regardless of the working conditions.

Caution

- ✓ **As bend-resistant wirings are used, so never use wirings other than the specified ones.**
- ✓ **Replace wirings on a unit-by-unit basis for individual units.**
- ✓ **Do not use cables, protection springs, hoses, etc., if they have external damage, other types of damage, etc. because they can cause troubles.**
- ✓ **When purchasing the internal wirings for the manipulator, contact our service department about the wiring type.**
- ✓ **Specify the length of the wirings from the manipulator to the controller.**

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6 Troubleshooting

6.1. How to Investigate the Causes of Troubles

When an abnormality occurs during the operation the robot, and if it is not a problem with the controller, it is a problem attributable to damaged mechanical parts. To handle troubles easily and quickly, it is required to first accurately identify the phenomenon and determine to which parts the defects are attributable.

(1) Step 1: Which axis has the abnormality?
First, check which axis has an abnormal phenomenon. When a strange phenomenon does not appear during the operation and it is difficult to judge, you should investigate the following items.

- Is there any area where an abnormal sound is generated?
- Is there any area where abnormal heating occurs?
- Is there any part that has clearance?

(2) Step 2: Is there any damaged part?
If an axis with an abnormality is identified, investigate which part is the cause. There can be multiple causes for one phenomenon. Refer to [Table 6-1] for symptoms and causes of troubles shown on the next page.

(3) Step3: Handling defective parts
Dispose of parts that are found to be defective in the manner described in 『6.3 Methods to Investigate and Handle Each Part』. For matters other than those that can be handled by your company, please contact our service department.

6.2. Symptoms and Causes of Troubles

As shown in [Table 6-1], there can be multiple parts that are thought to be the cause of a single phenomenon.
Please refer to the next page to determine which parts are damaged.

Table 6-1 Symptoms and Causes of Troubles

Location of abnormality / Symptom of the trouble	Reducers	Brakes	Motors	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 and 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 min 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 occur 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. How to Investigate and Handle Each Part

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."**

6.3.1. Reducers

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 before the occurrence of the abnormality.
(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. Brake

When there is an abnormality in the brake, each axis may fall when the Operation Ready function in the [OFF] state. Or, on the contrary, the brake may operate even when the Operation Ready function in the [ON] state. Those situations will cause overload or noise.

When required to move the manipulator without turning the motor [ON], you should turn the brake release switch [ON] and then move the manipulator. At this time, because the robot arm will fall because of gravity, you should first take measures to prevent the arm from falling, and then turn the brake release switch [ON.]

- Investigation method

  While the Operation Ready function is in the [OFF] state, you should check if the operation sound comes from the brake by turning [ON] and [OFF] the brake release switch. If the operation sound of the brake is not heard, the switch is considered to be disconnected (When turning [ON] and [OFF] the brake release switch, you should pay special attention to the falling of the arm. The brake release switch is located on the board on the door side that can be seen when you open the controller door.)

- Handling method

  Check the wiring, and if it is not disconnected, replace the motor.

6.3.3. Motor

If there is an abnormality in the motor, abnormal motions such as shaking when stopped, irregular cycle (pulsation), and vibration during operation may occur. In addition, abnormal heating and abnormal sound may occur.

Considering that a similar phenomenon occurs even when the reducer is damaged, you should investigate the reducer and bearing at the same time to determine where the cause is.

You must fix the arm with a fall-prevention bolt or pin before the work so that the arm does not fall when you replace the motor.

- Investigation method

  Investigate whether there is any abnormal sound or abnormal heating.

- Handling method

  Replace the motor.

6.3.4. Encoder

If an encoder has an abnormality, it may cause position deviation, false operation, runaway, etc., which may lead to shaking when stopping or irregular pulsation. In addition, these troubles have nothing to do with the occurrence of mechanical abnormal sound, heating and vibration.

- Investigation method

  ① Investigate whether there is any abnormality in the encoder data.
  ② Set to the reference position of the adjustment scale and check whether there is any error in the position data.
  ③ While moving each axis of the robot, investigate whether there is an axis showing an irregularity in the data.
  ④ Investigate whether an error does not occur when the servo amplifier board, BD542 is replaced.

- Handling method

  ① Check the wiring, and if it is not disconnected, replace the encoder.
  ② If no error occurs when the servo amplifier board BD542 is replaced, it is required to replace the servo amplifier board.

6.3.5. Gas springs

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. Replacing the Motor

Caution

This robot has a brake built into the motor to maintain the posture of the arm, so the arm will fall if the motor is removed. You must take safety measures such as hanging the arm using a crane or inserting fixing pins to fix the first and second arms to prevent the falling.

When required to contact the motor right after the robot stops, you should check its temperature. The weight of the motor is as follows. Be careful when transporting the motor.

Table 6-2 Motor Weight by Axis

Axis	S	H	V	R2	B	R1
Weight (kg)	23,7	23,7	23,7	9.5	9.5	9.5

Caution

Part of this work is to be performed in the Operation Ready [ON] state. Therefore, two people should work in one group. One person should be in a position to press the emergency stop button at any time, and the other person should perform the work quickly while paying special attention to the motion of the robot. Also, before starting the work, check the place to which you can evacuate from danger.

6.4.1. Necessary Tools and Parts

Table 6-3 Necessary Tools

Tool name	Axis name	Part name (type)	Remarks
Torque wrench (to be prepared by the customer)	S, H, V	M8 torque wrench (lock type) M12 torque wrench (lock type)	Use of torque wrenches and extensions available 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	Applicable for	Part name (type)
Fall-prevention bolt (option)	H axis and V axis	○	M20×250 (standard)
	Wrist axes (R2, B, and R1)	-	-

(Precise origin setting can be performed using a level gauge during the overhauling of the robot. If precise origin setting is required, please contact us.)

6.4.2. How to Replace the Motor

Caution

This robot has a brake built into the motor to maintain the posture of the arm, so the arm will fall if the motor is removed. You must take safety measures such as hanging the arm using a crane and inserting fixing bolts to fix the first and second arms to prevent the falling.

(1) Set the controller to the teaching mode and set the Operation Ready function to the [ON] state. If it is impossible to set the Operation Ready function to the [ON] state, you should make sure that the arm does not fall and that the arm is sufficiently fixed. After that, you can perform the work starting from step (4.)

(2) Put the axis that requires the replacement of the motor into the basic posture.

(3) For the main axes (S, H, V): Refer to [Figures 6.1–6.4.]
For H and V axes, insert the fixing bolts to prevent the arm from falling.
For the wrist axes (R2, B, and R1): Set the origin of each axis by using the scale.

(4) Turn [OFF] the power of the controller and then turn [OFF] the primary power.

(5) Separate the motor wirings.

(6) Separate the motor from the manipulator by removing the motor attachment bolts.
When removing the motors of H and V axes, you should make sure that the lip of the oil seal is not damaged by the gear attached on the axis of the motor.

(7) Separate the gear attached on the axis of the motor.
At this time, take precautions not to allow a strong impact to be applied to the axis of the motor.

(8) Apply a thin layer of grease to the axis of the motor to be assembled and assemble the gear.
At this time, the bolts to be used to fasten the gear to the axis of the motor should be cleaned and degreased and applied with anti-loosening bond (Loctite 243) to the screw and then tightened with the prescribed torque using a torque wrench. In addition, the bolts should be slowly tightened in the symmetrical order.

(9) Apply a small amount of grease to the lip of the oil seal and an appropriate amount of grease to the tooth surface of the gear, and then assemble the motor to the manipulator. When attaching the motors of the main axes, you should make sure that the lip of the oil seal is not damaged by the gear attached to the axis of the motor.

(10) Connect the wiring of the motor.

(11) When the motors of the H and V axes are replaced, replenish new grease as much as the amount of leaked grease.

(12) Reset the encoder of the axis for which the motor has been replaced.

Cautions

Before calibrating the encoder, you should set the Operation Ready function to the [ON] state, and then press the Enable switch of the teach pendant for 2~3 seconds to check if the power is turned on.

(13) Calibrate the encoder of the axis for which the motor has been replaced by referring to the [Calibrating the Encoder] section in the Controller Operation Manual.

(14) Disassemble the M20 bolts, which are designed for preventing the arms of H and V axes from falling.

(15) Check whether there is any abnormality.

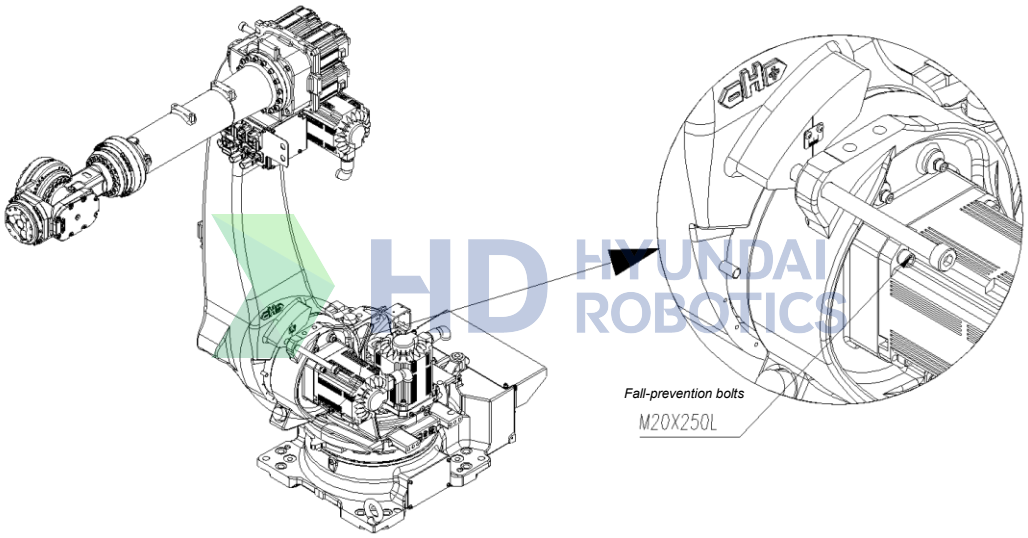

Figure 6.1 Position for Inserting the Fixing Bolt for the Primary Arm (H Axis)

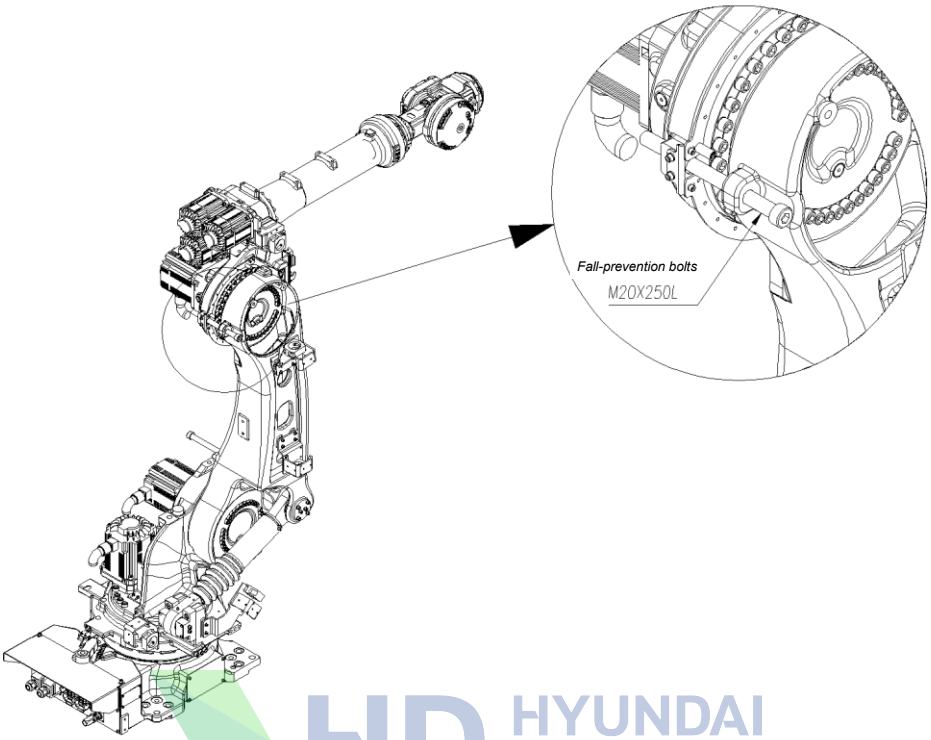

Figure 6.2 Position for Inserting the Fixing Bolt for the Secondary Arm (V Axis)

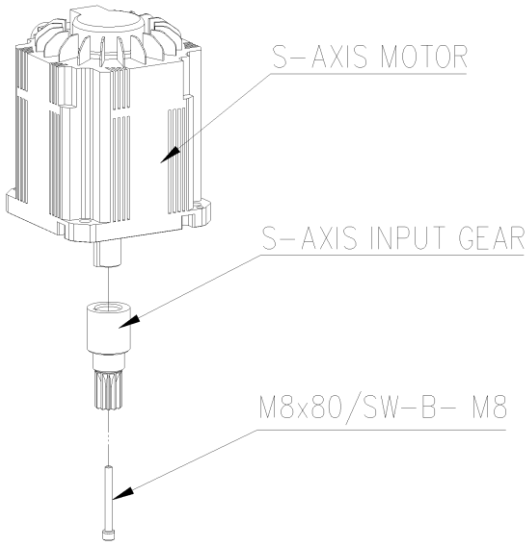

Figure 6.3 S-Axis Motor Assembly

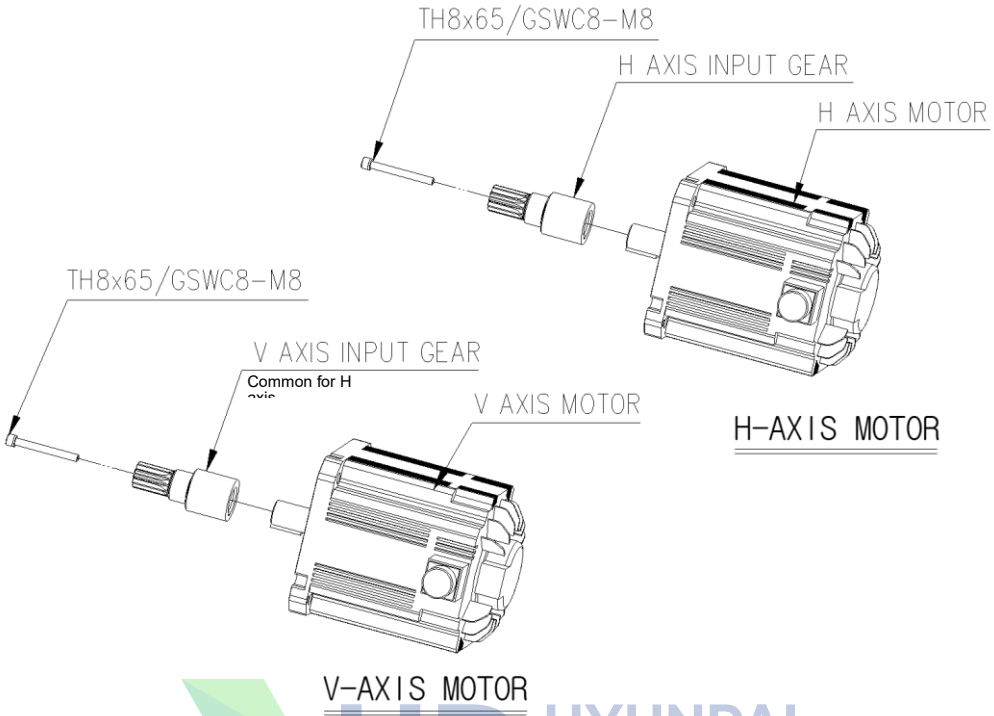

Figure 6.4 H-Axis and V-Axis Motor Assemblies

Caution

When the V-axis motor is being replaced, if the entire upper arm is not accurately attached to the mechanical stopper in the direction of gravity, the upper arm may rotate while the motor is being separated.

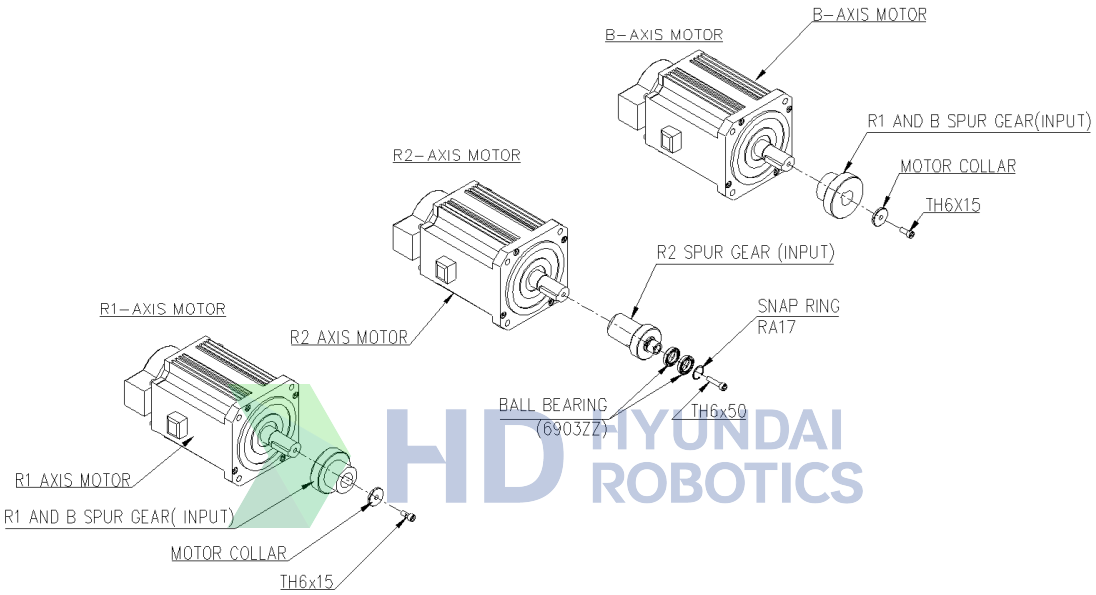

Figure 6.5 Wrist-Axis Motor Assembly

6.5. Setting the Encoder Origin

If the encoder data shows abnormal values because of some troubles or because of replacement of the motor, the origin of the robot should be set again.

The scale is used as a method for determining the posture and position of each axis of the robot. When the user has replaced the motor, the user should set the encoder by using the origin setting scale for each axis.

Cautions

Part of this work is to be performed with the Operation Ready function in the [ON] state. Therefore, two people should work in one group. One person should be in a position to press the emergency stop button at any time, and the other person should perform the work quickly while paying special attention to the motion of the robot.
Also, before starting the work, check the place to which you can evacuate from danger.

6.5.1. Setting the Origin

(1) Set the controller to the teaching mode and set the Operation Ready function to the [ON] state. If it is impossible to set the Operation Ready function to the [ON] state, you should set the reference position of the robot by using the brake release switch.

(2) Move each axis into the default posture to match the line on the scale.

(3) Reset the encoder. For the encoder resetting method, refer to 『6.5.2 Resetting the Encoder.』

(4) Please calibrate the encoder. Refer to 『7.5.4 Resetting the Serial Encoder』 of the Controller Operation Manual.

(5) Check whether there is any problem with the operation of the robot.

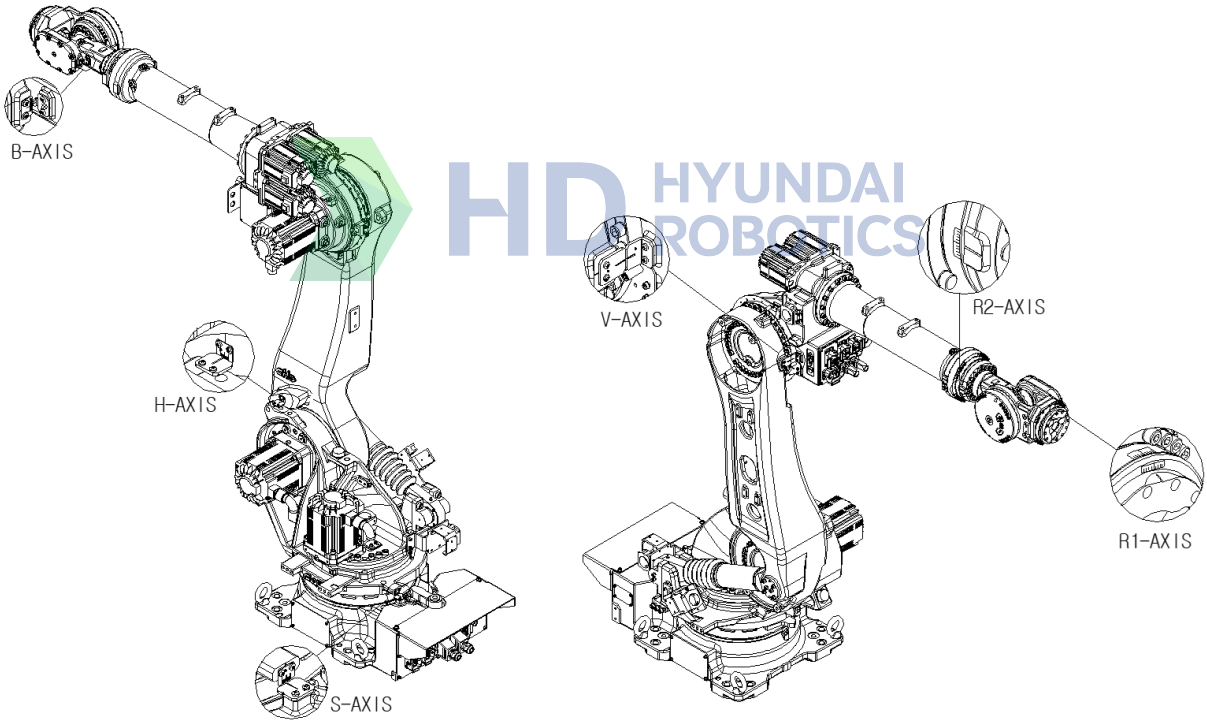

Figure 6.6 How to Reset the Origin

6.5.2. Resetting the Encoder

(1) Turn off the motor.

(2) Bring up the serial encoder resetting window (『[F2]: System』 → 『5: Initialize』 → 『4: Reset the Serial Encoder』.)

(3) Move to the targeted axis by using the [↓],[↑], and [SHIFT]+[←][→] keys. After that press the [Execute] key.

(4) After resetting the encoder, you must switch the controller power from the Off state to the On state.

6.5.3. Calibrating and Selecting the Encoder

- It is necessary to calibrate the encoder data at the reference position of each axis of the robot.
- Calibrate the encoder by referring to the 『Calibrating the Encoder』 section in the Controller Operation Manual.

[Screen for Encoder Calibration]

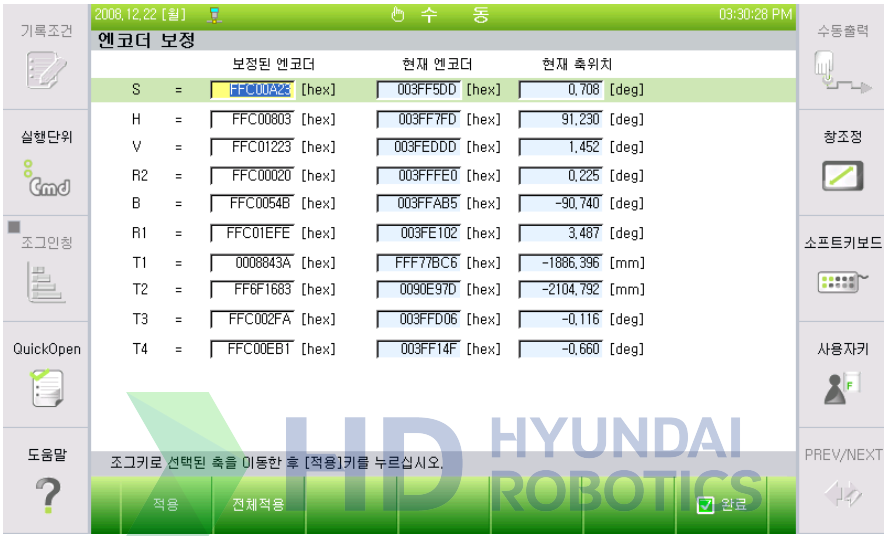

Table 6-5 Data Range after Resetting

Axis	Data Range after Resetting	Number of pulses per encoder revolution
All axes	0 ~ 8,191	8,192

(1) Select an axis and then move the axis to the reference position using the [Operate the Axis] key, then press the 『[F1]: Apply』 key.

(2) When you place every axis of the robot into the reference posture using the [Operate the Axis] key and press 『[F2]: Apply for All』 key, then the encoder offset calibration for all axes will be performed at once.

(3) To save the setting data, press 『[F7]: Complete』 key. If you press the [ESC] key, the changed data will not be saved.

Cautions

When calibrating the encoder data after replacing the motor, you should put the Power Ready function into the 『ON』 state and then check whether the power is inputted to the motor.

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7

Recommended Spare Parts

The table below shows the parts that are recommended as spare parts for the robot. When purchasing parts, check the serial number and manufacturing date of the manipulator and contact our service department.

[Classification]
A: Parts for regular maintenance (parts to be replaced regularly)
B: Main spare parts (recommended to be prepared as spare parts because of high frequency of operation)
C: Main components
D: Mechanical parts

Table 7-1 List of Spare Parts

Classification	Applicable robot	PLATE No.	Part name and specification	Quantity	Remarks
A	HS180 HS220 HS160L	R7900004400	GREASE VIGOGREASE RE0 1CAN=16KG	1	Common
A	HS180 HS220 HS160L	R7900054780	GREASE GADUS S2 V46 2 (1CAN=15KG)	1	Common
A	HS180 HS220 HS160L	R1001-6202-0P2	ENCODER BATTERY	6	Common
A	HS180 HS220 HS160L	R3200-7112-P01	MOTOR	1	S AXIS
B	HS180 HS220 HS160L	R3200-7212-P01	MOTOR	2	H/V AXES
B	HS180 HS220 HS160L	R3200-7312-P01	MOTOR	3	R2/B/R1 AXES
B	HS180 HS220 HS160L	R3200-7112-P02	REDUCER	1	S AXIS
B	HS180 HS220 HS160L	R3200-7212-P02	REDUCER	2	H/V AXES
B	HS180 HS220 HS160L	R3200-7312-P02	REDUCER	1	R2 AXIS
B	HS180 HS220 HS160L	R3200-7412-P01	REDUCER	1	B AXIS
B	HS180 HS220 HS160L	R3200-7412-P02	REDUCER	1	R1 AXIS

Classification	Applicable robot	PLATE No.	Part name and specification	Quantity	Remarks
C	HS180 HS220 HS160L	R3200-7412-001	WRIST ASSY	1	WRIST ASSY
C	HS180 HS220 HS160L	R3200-7112-112	INPUT GEAR(S)	1	FOR S-AXIS MOTOR
C	HS180 HS220 HS160L	R3200-7212-113	INPUT GEAR(H/V)	2	FOR H- AND V-AXIS MOTORS
C	HS180 HS220 HS160L	R3200-7312-136	R2 SPUR GEAR(INPUT)	1	FOR R2-AXIS MOTOR
C	HS180 HS220 HS160L	R3200-7312-138	R1 AND B SPUR GEAR(INPUT)	2	FOR B- AND R1-AXIS MOTORS
D	HS180 HS220 HS160L	R3200-7112-P03	BALL BEARING	1	FOR S-AXIS INPUT GEAR
D	HS180 HS220 HS160L	R3200-7212-P03	OIL SEAL	2	FOR H- AND V-AXIS INPUT GEARS
D	HS180 HS220 HS160L	R3200-7312-P07	BALL BEARING	2	FOR R2-AXIS SPUR GEAR
C	HS180 HS220 HS160L	R3200-7512-001	CABLE ASSY	1	CABLE ASSY
C	HS180 HS220 HS160L	R3200-7230-002(1),(2)	GAS SPRING & BS JOINT & PLASTIC (COVER)	1	FOR GAS SPRING
C	HS180 HS220 HS160L	R3200-7230-R01,R02	PRESSURE TESTER(FOR MEASURING THE GAS SPRING PRESSURE)	1	option (FOR GAS SPRING)
C	HS180 HS220 HS160L	R3200-7230-R05,R06	REPLENISHING ARMATURE KIT - APPLICABLE WHEN THE PRESSURE OF THE NITROGEN GAS BOMBE EXCEEDES 150 BAR - ITEMS TO BE INCLUDED WHEN ORDERING: SPECIFICATION FOR THE SCREW FOR THE GAS BOMBE CONNECTION PART	1	option (FOR GAS SPRING)

Classification	Applicable robot	PLATE No.	Part name and specification	Quantity	Remarks
C	HS180 HS220 HS160L	R3200-7230-R03,R04	GAS BOOSTER KIT - APPLICABLE WHEN THE PRESSURE OF THE NITROGEN GAS BOMBE IS 150 BAR OR LESS - ITEMS TO BE INCLUDED WHEN ORDERING: SPECIFICATION FOR THE SCREW FOR THE GAS BOMBE CONNECTION PART	1	option (FOR GAS SPRING)
D	HS180 HS220 HS160L	R3200-7230-P02	Spherical Bearing	2	FOR GAS SPRING
D	HS180 HS220 HS160L	R3200-7230-P03	Nilos Ring	4	FOR GAS SPRING
D	HS180 HS220 HS160L	R3200-7112-P07	O-RING	1	FOR S-AXIS REDUCER
D	HS180 HS220 HS160L	R3200-7212-P05	O-RING	2	FOR H- AND V-AXIS REDUCERS
D	HS180 HS220 HS160L	R3200-7212-P06	O-RING	2	FOR H- AND V-AXIS REDUCERS
D	HS180 HS220 HS160L	R3200-7312-P17	O-RING	2	FOR R2- AND B-AXIS REDUCERS
D	HS180 HS220 HS160L	R3200-7412-P12	O-RING	2	FOR R2- AND B-AXIS REDUCERS
D	HS180 HS220 HS160L	R3200-7412-P10	O-RING	1	FOR R1-AXIS REDUCER
D	HS180 HS220 HS160L	R3200-7112-P05	O-RING	1	FOR S-AXIS MOTOR
D	HS180 HS220 HS160L	R3200-7212-P04	O-RING	2	FOR H- AND V-AXIS MOTORS
D	HS180 HS220 HS160L	R3200-7312-P15	O-RING	3	FOR R2-, B-, AND R1-AXIS MOTORS
D	HS180 HS220	R3200-7230-R07,R12	REPAIR KIT(FOR DISASSEMBLING THE	1	option (FOR GAS

Classification	Applicable robot	PLATE No.	Part name and specification	Quantity	Remarks
	HS160L		INTERNAL PARTS OF THE GAS SPRING)		SPRING)
D	HS180 HS220 HS160L	R3200-7230-R08,R09	REPLACEMENT CATRIDGE(GAS SPRING)	1	option (FOR GAS SPRING)
D	HS180 HS220 HS160L	R3200-7230-R10,R11	REPLACEMENT PISTON ROD(GAS SPRING)	1	option (FOR GAS SPRING)
D	HS180 HS220 HS160L	R3200-7412-P03	TAPER BEARING	4	R1-AXIS B/G(1)
D	HS180 HS220 HS160L	R3200-7412-P07	BALL BEARING	2	R1-AXIS (B/G) SPLINE SHAFT
D	HS180 HS220 HS160L	R3200-7312-P11	BALL BEARING	1	R2-AXIS INPUT GEAR
D	HS180 HS220 HS160L	R3200-7312-P03	BALL BEARING	1	R1-AXIS SPLINE SHAFT
D	HS180 HS220 HS160L	R3200-7312-P04	BALL BEARING	1	R1-AXIS SPLINE SHAFT
D	HS180 HS220 HS160L	R3200-7312-P05	BALL BEARING	1	R1-AXIS SPLINE SHAFT
D	HS180 HS220 HS160L	R3200-7312-P06	BALL BEARING	2	R1-AXIS SPLINE SHAFT
D	HS180 HS220 HS160L	R3200-7412-P06	BALL BEARING	1	R1-AXIS (B/G) SPLINE SHAFT
D	HS180 HS220 HS160L	R3200-7312-P08	BALL BEARING	1	B-AXIS SPLINE SHAFT
D	HS180 HS220 HS160L	R3200-7412-P17	BALL BEARING	1	B-AXIS GEAR SHAFT
D	HS180 HS220 HS160L	R3200-7412-P05	BALL BEARING	1	B-AXIS GEAR SHAFT
D	HS180 HS220 HS160L	R3200-7312-P09	BALL BEARING	1	B-AXIS PIPE

Classification	Applicable robot	PLATE No.	Part name and specification	Quantity	Remarks
D	HS180 HS220 HS160L	R3200-7312-P10	BALL BEARING	1	R2-AXIS PIPE
D	HS180 HS220 HS160L	R3200-7412-P04	BALL BEARING	1	R1-AXIS MAIN BRG SHAFT
D	HS180 HS220 HS160L	R3200-7312-P12	OIL SEAL	1	R1-AXIS SPLINE SHAFT
D	HS180 HS220 HS160L	R3200-7312-P13	OIL SEAL	1	B-AXIS SPLINE SHAFT
D	HS180 HS220 HS160L	R3200-7312-P14	OIL SEAL	1	R2-AXIS INPUT GEAR
D	HS180 HS220 HS160L	R3200-7412-P08	OIL SEAL	1	R1-AXIS MAIN BRG SHAFT
D	HS180 HS220 HS160L	R3200-7112-P04	OIL SEAL	1	S-AXIS CABLE HOLLOW
D	HS180 HS220 HS160L	R3200-7312-P16	O-RING	1	ARM PIPE+ARM FRAME
D	HS180 HS220 HS160L	R3200-7412-P09	O-RING	1	R1-AXIS MAIN BRG SHAFT
D	HS180 HS220 HS160L	R3200-7112-P06	O-RING	1	S-AXIS CABLE HOLLOW
D	HS180 HS220 HS160L	R1001-6202-P1a	LIMIT SWITCH	1	OPTION (S AXIS)
D	HS180 HS220 HS160L	R1001-6202-P1b	LIMIT SWITCH	2	OPTION (H AND V AXES)

8 Disassembling

8.1. Materials of Individual Parts of the Robot

The robot is made of various materials as shown in the table below. To prevent adverse effects on human health or the environment, some parts should be properly, orderly and sealed.

Table 8-1 Table of Materials for Each Part

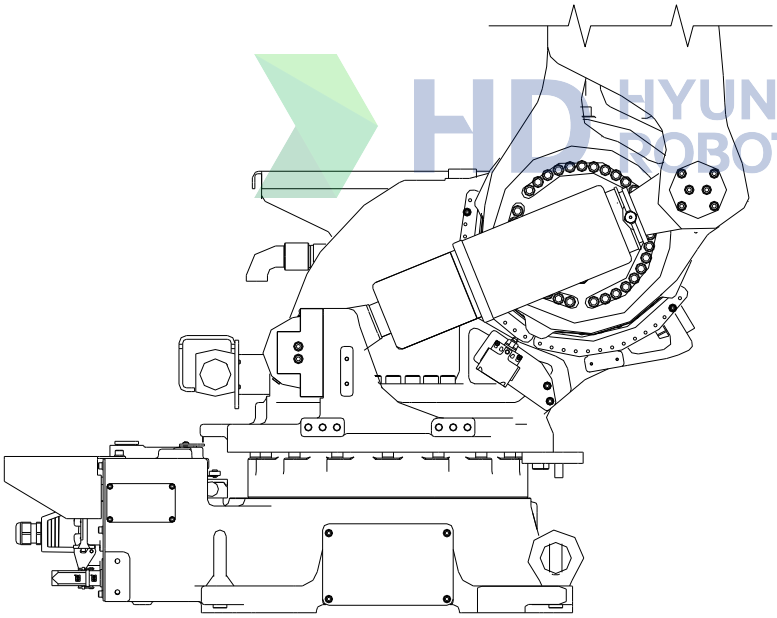
Part	Material
Battery	NiCad or Lithium
Wiring, Motor	Copper
Base body, Lower Frame, Upper Frame etc.	Cast Iron
Brakes, Motors	Samarium Cobalt(or Neodymium)
Wiring, Connectors	Plastic / Rubber
Reducers, Bearings	Oil / Grease
Wrist cover etc.	Aluminum alloy cast

8.2. Disposing of the Gas Spring

As gas springs are assembled with a high compression force, if the following procedures are not followed during the disposal stage, damage to life and property may occur. So you must observe the procedures for disposal.

8.2.1. Separating the Gas Spring

When separating the gas spring, you must keep the H axis in the posture shown in the figure below. In this posture, the compression force of the gas spring will be minimized so that it can be separated from the robot. Therefore, even if the gas spring is separated from the manipulator, the compression force by the spring will be in balanced state, so the risk factors in the separation process will be minimized.
However, when required to separate the gas spring for disposing of it or repairing its internal parts, you should first remove the gas completely in accordance with the procedure for discharging gas from the gas spring.

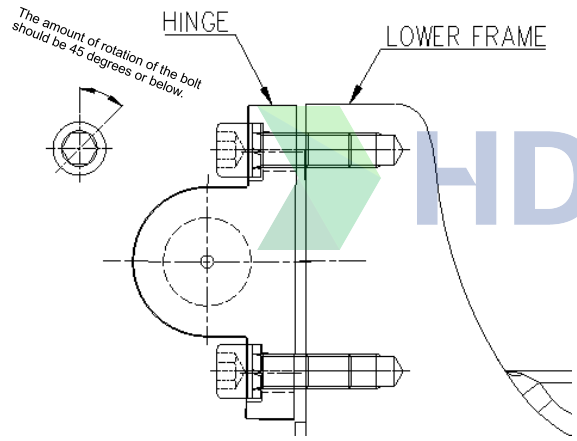


S- Axis	0
H- Axis	90
V- Axis	0
R2- Axis	0
B- Axis	0
R1- Axis	0

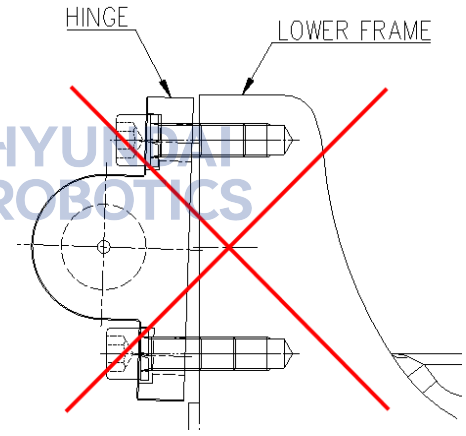
Figure 8.1 Posture for Separating the Gas Spring

Caution

- ✓ **When fastening or loosening the hinge bolts to separate or disassemble the gas spring, you need to rotate the upper and lower bolts alternately at less than 45 degrees as shown in the figure below to prevent the hinge from being excessively tilted.**
  Excessive tilting of the hinge will damage the bolt screw, and thus damaged bolt screw will damage even the tap of the lower frame, making it difficult to perform the disassembling and assembling works.
- ✓ **The shape of each part, such as the hinge, may change according to the design for mass production.**



[The amount of rotation of the bolt is 45 degrees or below: Approved]



[The amount of rotation of the bolt is 45 degrees or above: Not approved]

8.2.2. Disposing of the Gas Spring

Because the inside of the gas spring separated from the manipulator is still assembled with a high compression force, you should completely remove the gas according to the procedures of 9.3 Releasing the Gas of the Gas Spring, and then confirm that the gas is completely removed and then dispose of the gas spring. Also, because a small amount of grease will still remain inside, you should handle it in accordance with the relevant laws and regulations in an environment sensitive to contamination.

9

Maintaining the 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.

Caution

- ✓ 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 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 as well as with appropriate trainings and understanding of the product. Please contact us for any inquiries regarding this.

9.1. Checking the Pressure of the Gas Spring

(1) Set the robot to the 90° posture, and cut off the power of the controller.

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

(3) Check whether the handle of the bleed valve ⓟ is closed (clockwise.)

(4) Check whether the gas release pin of the part marked as ⓡ is protruding. If it is protruding, turn the knob ⓞ counterclockwise to prevent the pin from protruding.

(5) Set the release pin ⓡ of the pressure tester (= armature) to the center of the gas inlet, and then turn the knob ⓝ clockwise to completely connect it.

(6) Turn the knob ⓞ clockwise and then stop turning it if the pointer of the pressure gauge ⓣ moves.
(To avoid making the release pin ⓡ go inside excessively and damage the valve inside the gas spring, do not turn the knob ⓞ excessively.)
The gas pressure in accordance with the surface temperature of the gas spring is shown in the table below.

(7) Check the pressure and then turn the knob ⓞ counterclockwise to retreat it. After that, turn the bleed valve ⓟ counterclockwise to discharge the residual gas inside the pressure tester.

(8) Turn the knob ⓝ of the pressure tester counterclockwise to separate it. After that, install the plug back.

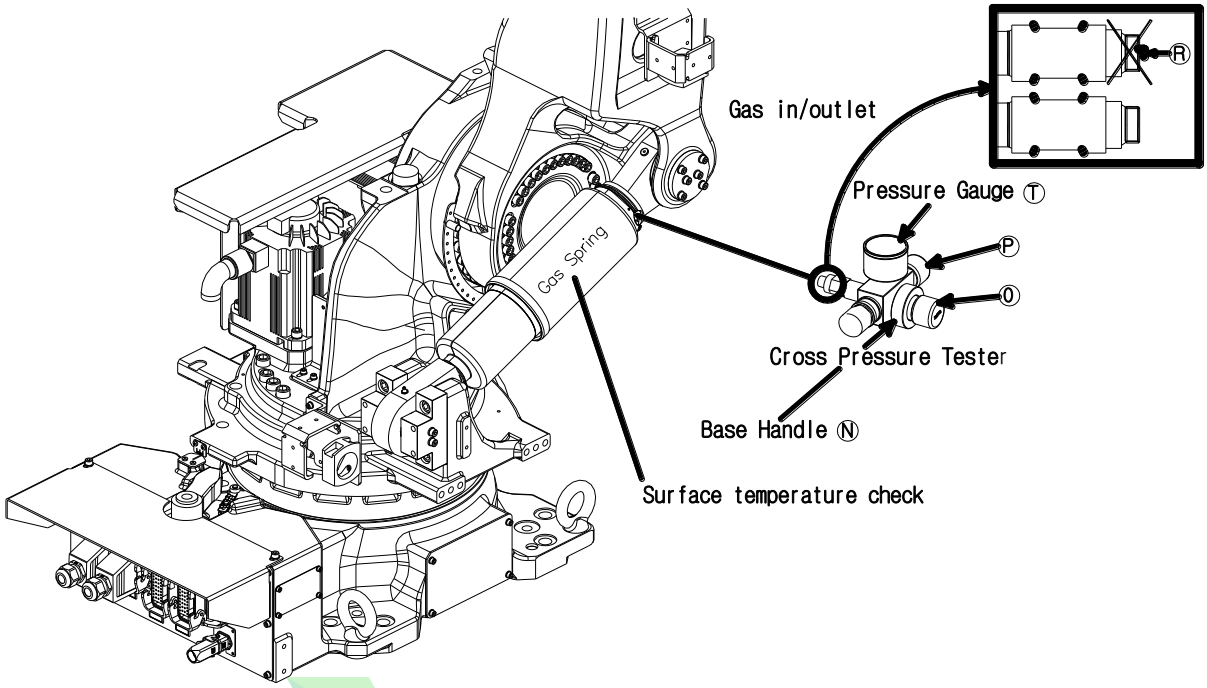


Figure 9.1 Checking the Pressure of the Gas Spring

Table 9-1 Pressure for Each Gas Spring Surface Temperature – The 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 is reduced by about 0.5 bar.
The cross pressure tester (pressure tester = armature) may have different names and handle positions depending on the type.

9.2. Replenishing the Gas of the Gas Spring

Caution

- ✓ Nitrogen gas is filled at high pressure, so the safety regulations of the concerned country should be observed.
- ✓ Fill only nitrogen gas.
  (Never charge other types of gas but also liquid nitrogen.)
- ✓ Must wear safety glasses when working.
- ✓ Never look directly into the gas inlet and pressure gauge.
- ✓ Replenishment and charging of the gas must be carried out while the gas spring has been assembled on the robot.
- ✓ After charging the gas, allow about 30 minutes for the gas temperature to return to room temperature before the use.
- ✓ 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.

9.2.1. When the Pressure of the Nitrogen Gas Bombe Exceeds 150 bar

(1) Set the robot to the 90° posture, and cut off the power of the controller.

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

(3) Check that the bleed valve ⑭ and shut-off valve [⑫ of the pressure tester are closed (locked clockwise.)

(4) Turn the knob ⑩ counterclockwise to prevent the release pin ⑧ from protruding.

(5) Turn the knob ⑨ of the pressure tester clockwise to completely connect it to the gas inlet.

(6) Check whether the handle ⑪ and shut-off valve ⑫ are closed.

(7) Connect the screw of the connection part of the regulator to the screw of the nitrogen gas bombe.
(Hoses should be connected as shown in the figure.)
Each country has different specifications for the screw of the nitrogen bombe, you should purchase a regulator that meets the specifications for the screw of the nitrogen bombe.
If the pressure of the nitrogen gas bombe is 150 bar or below, a booster should be fitted as well as a regulator (Condition for a nitrogen gas bombe that can perform the charging without a booster: It can keep the pressure at 150 bar or more and be capable of charging the gas spring with the pressure of 140 bar.)

(8) The gauge ⑬ indicates the set gas pressure, and the gauge ⑮ the pressure of the nitrogen gas

bombe.

(9) Open the knob ⑦of the nitrogen gas bombe, and then turn the handle ⑪ of the regulator (⑫)to set the set gas pressure (the set gas pressures are shown in Table 9.1 Pressure For Each Gas Spring Surface Temperature – The Set Gas Pressure.)

(10) Open the shut-off valve ⑨slowly and perform the charging until the pressure gauge ⑪ reaches the set pressure.

(11) When the set pressure is reached, close the shut-off value ⑨and then open the bleed valve ⑩to release the residual pressure inside the pressure tester.

Do not unscrew the bleed valve ⑩more than 360° .

(12) Close the bleed valve ⑩to adjust the gas pressure in the gas spring.

(13) While slowly turning the knob ⑥ clockwise, check the pressure on the pressure gauge.⑪ Take precautions not to allow the release pin ⑧to go inside excessively and damage the valve mounted on the gas spring.

(14) When the set pressure is exceeded, you should adjust the gas pressure to the desired pressure by opening and closing the bleed valve ⑩little by little.

(15) Turn the knob ⑥counterclockwise to retreat the release pin ⑧.

(16) When the pressure is checked, the bleed valve ⑩should be opened to completely release the residual pressure inside the pressure tester.

(17) Close the knob ⑦of the nitrogen gas bombe and loosen the regulator connection part to separate it from the nitrogen gas bombe.

(18) Loosen the shut-off connection part to separate it from the pressure tester.

(19) Turn the knob ⑬of the pressure tester counterclockwise to disconnect it from the gas spring.

(20) Check the check valve of the gas spring for oil leakage or gas leakage.
Warning! Do not look directly into the check valve hole if the gas bombe is filled with gas.

(21) Connect the G1/8 plug to the gas spring.
After charging the gas, allow about 30 minutes for the gas temperature to return to room temperature before the use.

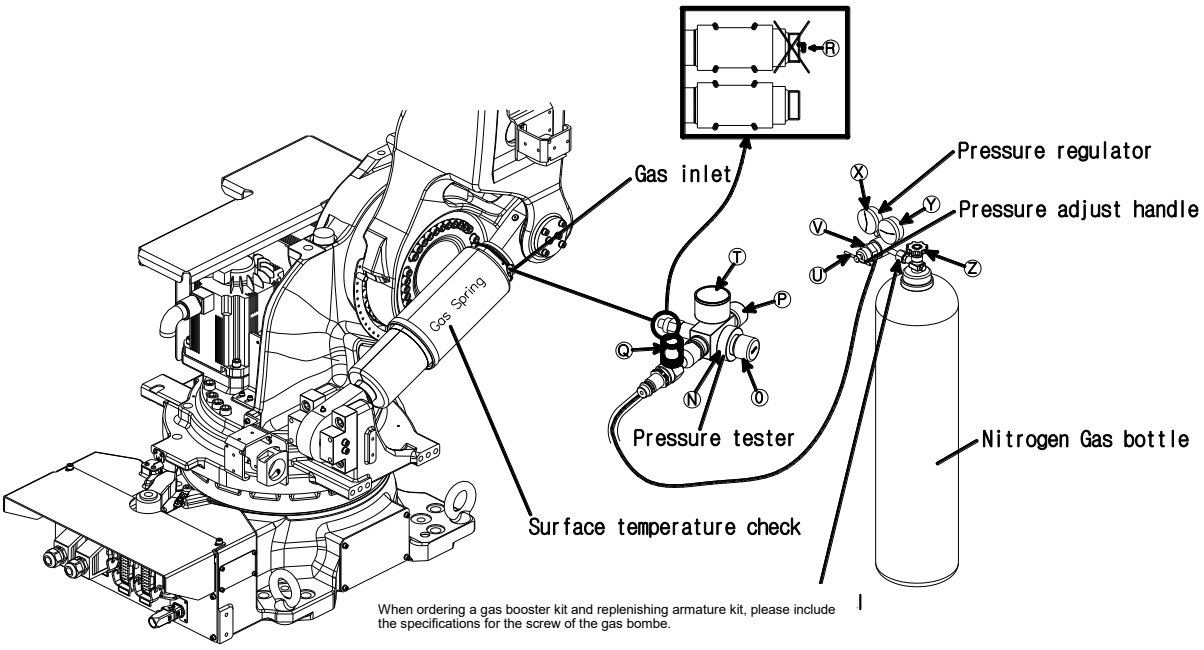


Figure 9.2 Replenishing the Gas of the Gas Spring

The gas replenishing kit may vary in shape and name depending on the type, so please refer to the manual enclosed when you purchased it.

9.2.2. When the Pressure of the Nitrogen Gas Bombe is 150 Bar or Below (Replenishing the Gas by Using the Booster)

(1) Set the robot to the 90° posture, and cut off the power of the controller.

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

(3) Check that the bleed valve ⓟ and shut-off valve ⓠ of the pressure tester are closed (locked clockwise.)

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

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

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

(7) Connect the screw of the connection part of the regulator to the screw of the nitrogen gas bombe.
(The connection parts of hoses should be connected to each connection inlet.)
Each country has different specifications for the screw of the nitrogen bombe, you should purchase a regulator that meets the specifications for the screw of the nitrogen bombe.

(8) The gauge ⑧ indicates the set gas pressure of the nitrogen gas bombe, and the gauge ⑨ indicates the pressure of the nitrogen gas bombe.

(9) Open the knob ⑦ of the nitrogen gas bombe, and then turn the handle ⑪ of the regulator (⑨)to set the set gas pressure (the set gas pressures are shown in Table 9.1 Pressure For Each Gas Spring Surface Temperature – The Set Gas Pressure.)

(10) Open the shut-off valve Ⓦ of the hose connected to the regulator ⑨ and slowly turn the shut-off valve ⑫ to be connected to the pressure tester counterclockwise until the pointer of the pressure gauge ⑩ matches the pointer of the gauge ⑧.

(11) Connect the connection part of the air hose to the booster and then open the knob Ⓢ (the knob of the air hose owned by the customer)to operate the booster.
Charge until the pointer of the pressure gauge ⑩ reaches the set pressure.
※ During the charging, the minimum air pressure should be 5 bar or more
Replace the nitrogen gas bombe when the residual pressure is 30 bar or less.

(12) When the set pressure is reached, close the shut-off value ⑫ and then open the bleed valve ⑭ to release the residual pressure inside the pressure tester.

(Do not unscrew the bleed valve ⑭ more than 360° .)

(13) Close the bleed valve ⑭ and turn the knob ⑬ clockwise little by little while checking that the pointer of the pressure gauge ⑩ matches the set pressure. If they are matching, stop the work. Take precautions not to allow the release pin ⑮ to go inside excessively and damage the check valve mounted on the gas spring.

(14) When the set pressure is exceeded, you should adjust the gas pressure to the desired pressure by opening and closing the bleed valve ⑭ little by little.

(15) Turn the knob ⑬ counterclockwise to retreat the release pin ⑮.

(16) When the pressure is checked, the bleed valve ⑭ should be opened to completely release the residual pressure inside the pressure tester.

(17) Close the knob Ⓢ of the air hose and separate it from the booster.

(18) Close the shut off valve Ⓦ of the hose connected to the regulator and close the handle ⑪.

(19) Close the knob ⑦ of the nitrogen gas bombe and separate the hose connected to the

regulator ⑰ from the booster. After that, open the shut-off value to completely release the residual pressure remaining inside.

(20) Separate the shut-off valve connection part from the pressure tester.

(21) Turn the knob ⓝ of the tester pressure counterclockwise to disconnect from the gas spring. Connect the G1/8 plug to the gas spring.
After charging the gas, allow about 30 minutes for the gas temperature to return to room temperature before the use.

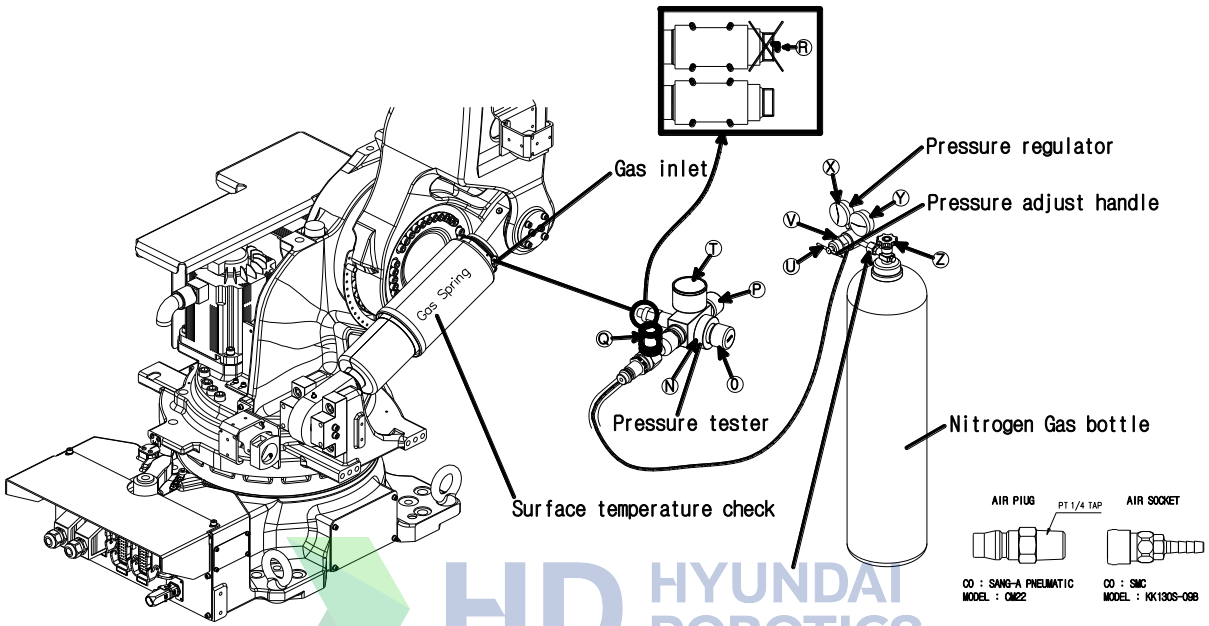


Figure 9.3 Replenishing the Gas of the Gas Spring by Using the Booster

The gas replenishing kit and the booster may vary in shape and name depending on the types, so please refer to the manual enclosed when you purchased them.

9.3. Releasing the Gas of the Gas Spring

You should release the gas of the gas spring in the following cases.

- When the gas spring needs to be separated from the robot, but the H axis cannot be operated, making it impossible to put the H axis at 90° .
- When required to transport the robot by air (The law restricts that air transport of machinery equipped with high-pressure equipment should be performed after depressurizing it.)

Caution

If the gas is rapidly released, colored oil inside the spring may be spurting out. You should wear protective glasses and carry out the releasing work slowly.

(1) Remove the plug installed to the gas inlet of the gas spring.

(2) Check whether the handle of the bleed valve Ⓟ is closed (clockwise.)

(3) Check whether the gas release pin of the part marked as Ⓡ is protruding. If it is protruding, turn the handle of the knob Ⓞ counterclockwise to prevent the pin from protruding.

(4) Turn the knob Ⓝ of the pressure tester clockwise to completely connect it to the gas inlet

(5) Turn the knob Ⓞ clockwise and then stop turning it if the pointer of the pressure gauge Ⓣ moves (To avoid making the release pin Ⓡ go inside excessively and damage the valve inside the gas spring, do not turn the knob Ⓞ handle excessively.)

(6) Turn the bleed valve Ⓟ counterclockwise slowly to completely release the gas.
Warning! Never look directly into the gas outlet.

(7) Turn the knob Ⓞ counterclockwise to retreat the release pin Ⓡ. After that, turn the knob Ⓝ of the pressure tester counterclockwise to separate it.

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

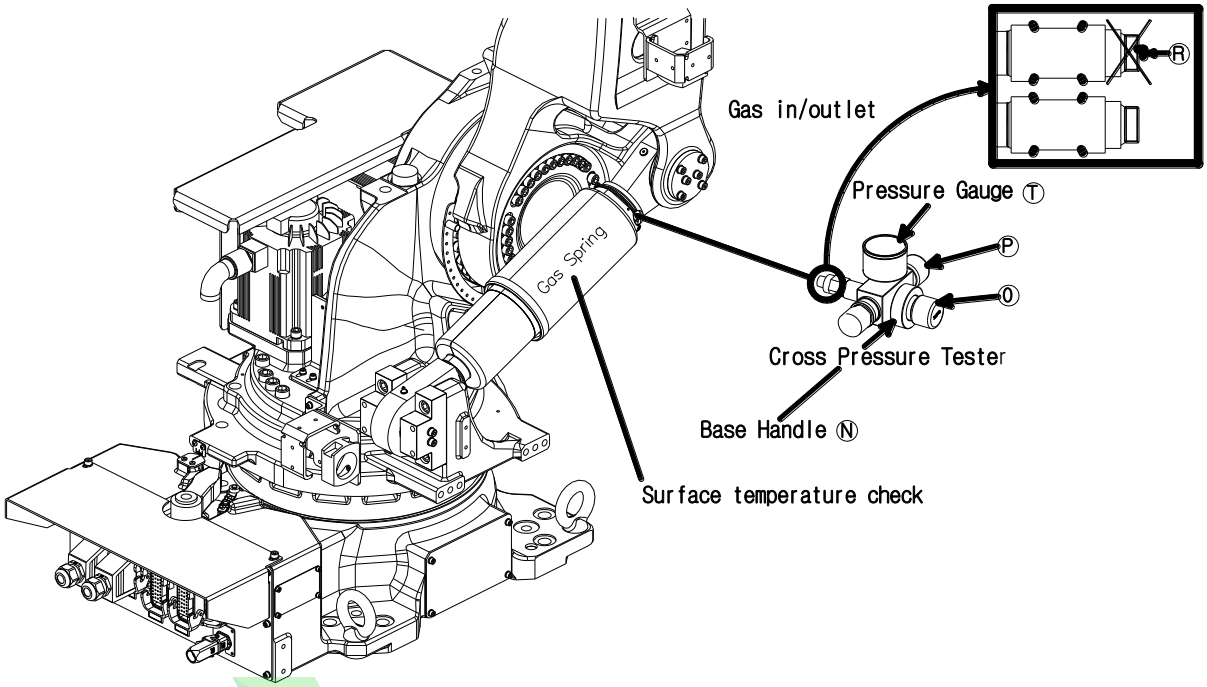


Figure 9.4 Releasing the Gas of the Gas Spring

9.4. Replacing (Separating and Assembling) the Gas Spring

When replacing the gas spring, you should replace the bearing assembled to the BS joint as well.

9.4.1. Separating the Gas Spring

You must keep the H axis at the posture as shown in [Figure 9.5] while separating the gas spring.
In this posture, the compression force of the gas spring will be minimized so that it can be separated from the robot.
Therefore, even if the gas spring is separated from the manipulator, the compression force by the spring will be in balanced state, so the risk factors in the separation process will be minimized.
However, when required to separate the gas spring for disposing of it or repairing its internal parts, or when impossible to put the H axis at 90° because the H axis does operate, you should remove the gas completely in accordance with the procedures of “9.3 Releasing the Gas of the Gas Spring.”

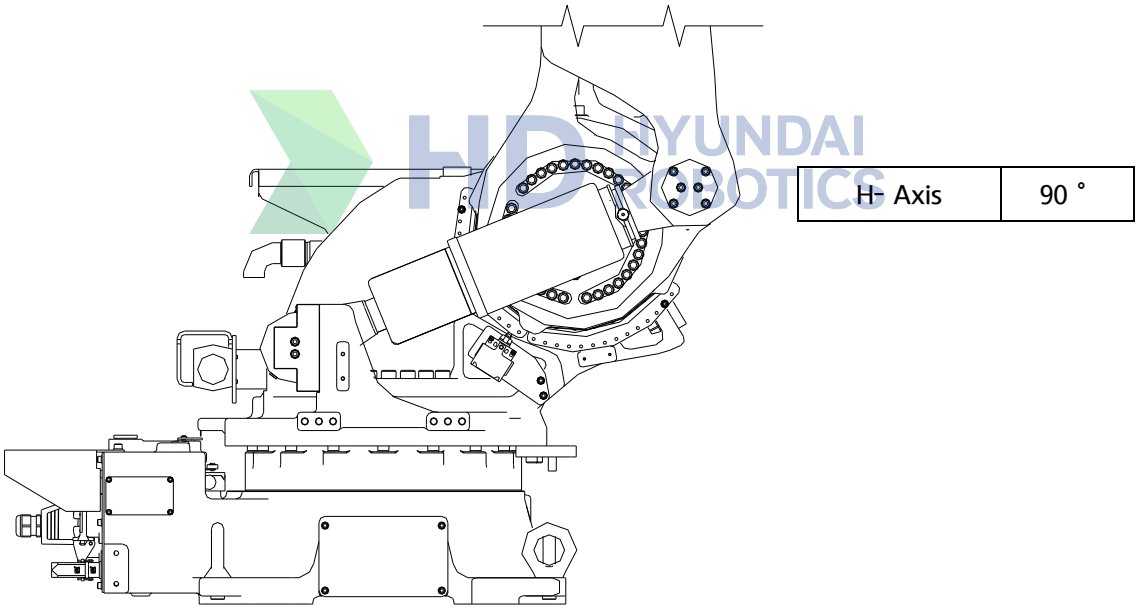
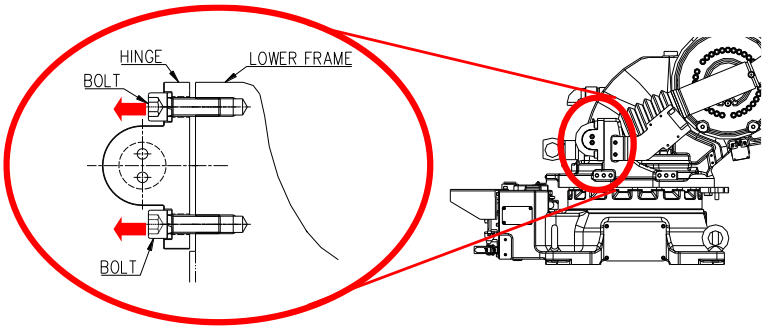


Figure 9.5 Posture for Separating the Gas Spring

[Danger]

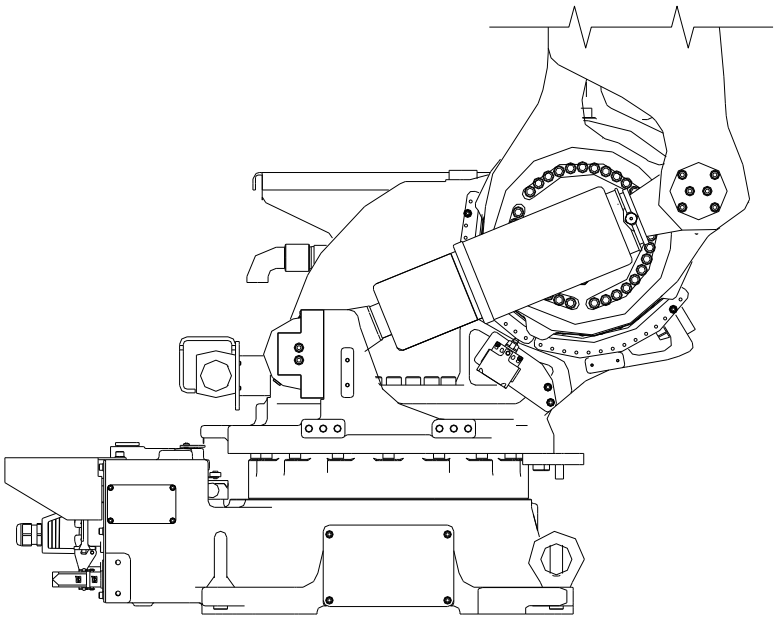
✓ Postures in which the gas spring must not be separated : Angles of the H axis other than 90 °

In the posture of the H axis at angles other than 90 ° , the compression force of the gas spring will be excessive, so when the bolt of the hinge is loosened, the screw thread will be damaged by the pressure of the gas spring and the bolt will be thrown out, causing accidents involving people and damage to the equipment.)



9.4.2. Assembling the Gas Spring

When required to assemble the gas spring, you must put the H axis in the posture shown in [Figure 9.6]. In this posture, the compression force of the gas spring will be minimized so that it can be assembled to the robot.

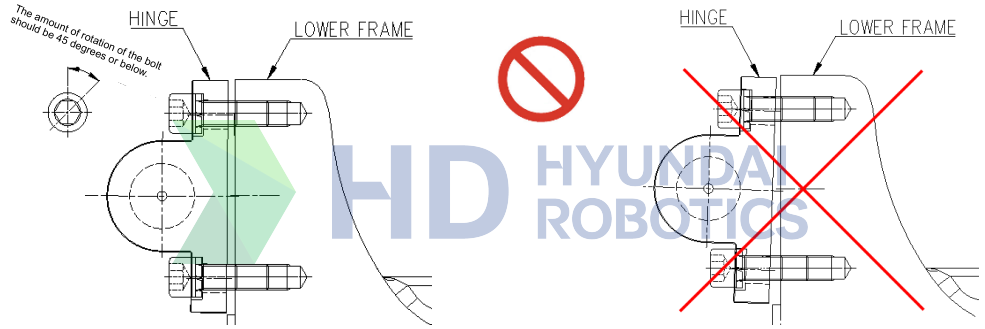


S- Axis	0
H- Axis	90
V- Axis	0
R2- Axis	0
B- Axis	0
R1- Axis	0

Figure 9.6 Posture for Assembling the Gas Spring

Caution

- ✓ **When fastening or loosening the hinge bolts to separate or disassemble the gas spring, you need to rotate the upper and lower bolts alternately at less than 45 degrees as shown in Figure 9.7 to prevent the hinge from being excessively tilted.**
- ✓ **Excessive tilting of the hinge will damage the bolt screw, and thus damaged bolt screw will damage even the tap of the lower frame, making it difficult to perform the disassembling and assembling works.**
- ✓ **The shape of each part, such as the hinge, may change according to the design for mass production.**



[When fastening the bolt by rotating it at 45 degrees or less: No damage to the screw occurs]

[When fastening the bolt by rotating it at 45 degrees or more: Damage to the screw occurs]

Figure 9.7 Precautions to Take in Fastening and Loosening the Hinge Bolt of the Gas Spring

9.4.3. Technical Data of the Gas Spring

Table 9-2 Technical Data of the Gas Spring

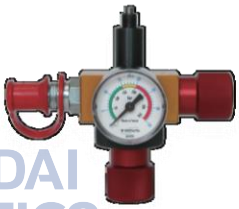
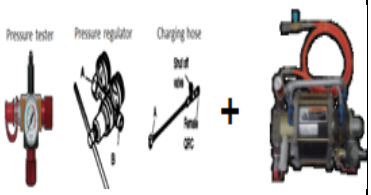
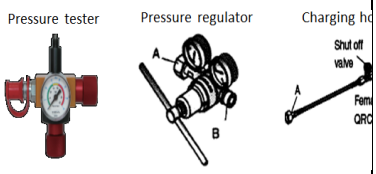
Classification	DATA			Remarks
	HS180	HS220	HS160L	
Pressure medium	Nitrogen gas/Hydraulic oil			
Stroke length	160mm			
Operating temperature	0 ℃ ~ 80 ℃			
Gas volume	0.9 liter			
Maximum charging pressure	140 bar			Based on spring surface temperature of 30℃
Proper working pressure	140 bar ~ 125 bar			Maintenance target pressure Based on spring surface temperature of 30℃
Minimum allowable pressure	105 bar			Based on spring surface temperature of 30℃
Weight	About 14 kg			

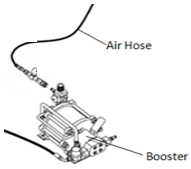
※ For the pressure, refer to Table 9-1 Pressure for Each Gas Spring Surface Temperature – The Set Gas Pressure

※ The minimum allowable pressure may change depending on the motor load of the robot.

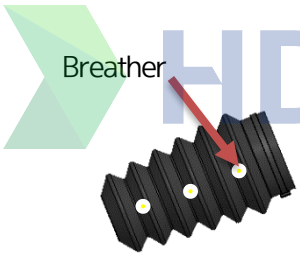
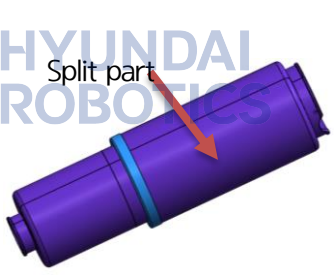
9.4.4. Parts for Gas Spring Pressure Measuring and Gas Charing

Table 9-3 Parts for Gas Spring Pressure Measuring and Gas Charing

Part name and specification	PLATE NO	Quantity per unit	Shape	Supplied by Classification
GAS SPRING & BS JOINT & PLASTIC(1) & Nipple	R3200-7230-002(1)	1		Hyundai Robotics (option)
Bearing Collar	R3200-7230-218	2		
Spherical Bearing 22208	R3200-7230-P02	2		
Nilos Ring 22208JV	R3200-7230-P03	4		
PRESSURE TESTER-1 (for measuring the pressure)	R3200-7230-R01	1		Hyundai Robotics (option)
REPLENISHING ARMATURE KIT-1 + GAS BOOSTER KIT-1 1. For charging the gas when the nitrogen gas bombe pressure is 150 bar or below 2. Item to be included when the customer orders : Specification for the connection part screw of the nitrogen gas bombe	R3200-7230-R05 + R3200-7230-R03	1		Hyundai Robotics (option)
REPLENISHING ARMATURE KIT-1 1. For charging the gas when the nitrogen gas bombe pressure exceeds 150 bar 2. Item to be included when the customer orders : Specification for the connection part screw of the nitrogen gas bombe	R3200-7230-R05	1		Hyundai Robotics (option)
GAS BOOSTER KIT-1 1. For increasing the pressure when the nitrogen gas bombe pressure is 150 bar or below 2. AIR INLET PLUG MALE : R1/4 3. Item to be included when the customer orders	R3200-7230-R03	1		Hyundai Robotics (option)

: Specification for the connection part screw of the nitrogen gas bombe				
Air hose and quick coupling (for supplying air)	-	1		Customer

9.4.5. Gas Spring Protection Cover

Classification	BELLOWS	Plastic Cover	Remarks
Appearance			
Material	Rubber (all-in-one type)	Plastic (split type)	
Required to disassemble the gas spring when replacing the protection cover	O	X	
Specification for the clamp	○ Small size: Cable tie ○ Large size: 12W x Φ103 ○ Wrench torque: - ○ Tightening torque: -	○ Small size: 12W x Φ54 ○ Large size: 12W x Φ103 ○ Wrench torque: 8mm ○ Tightening torque: 60kg/㎠	
Images of Clamps	General type 	General type 	
Time for replacement	When tearing occurs.	When damage because of an external impact occurs.	

Precautions for assembling	When assembling the replacement protection cover, you should make the breathing hole face the inside (robot side.) Perform assembling inwards (to the robot side)	Assemble in a way that there is no gap in the split part.	

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10

Diagram for Connection of Wirings inside the Manipulator

Wirings in the manipulator are branched for each unit, and a relevant connection diagram is shown for each. Please use them when checking or exchanging wirings.

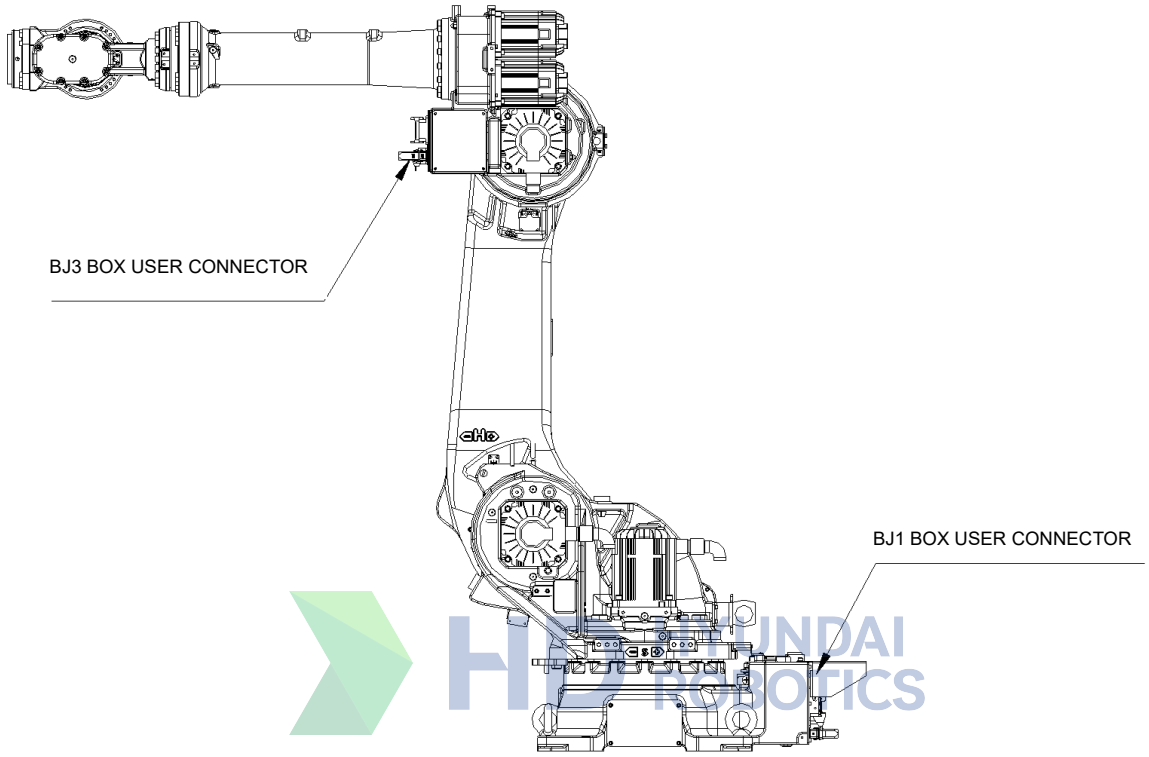
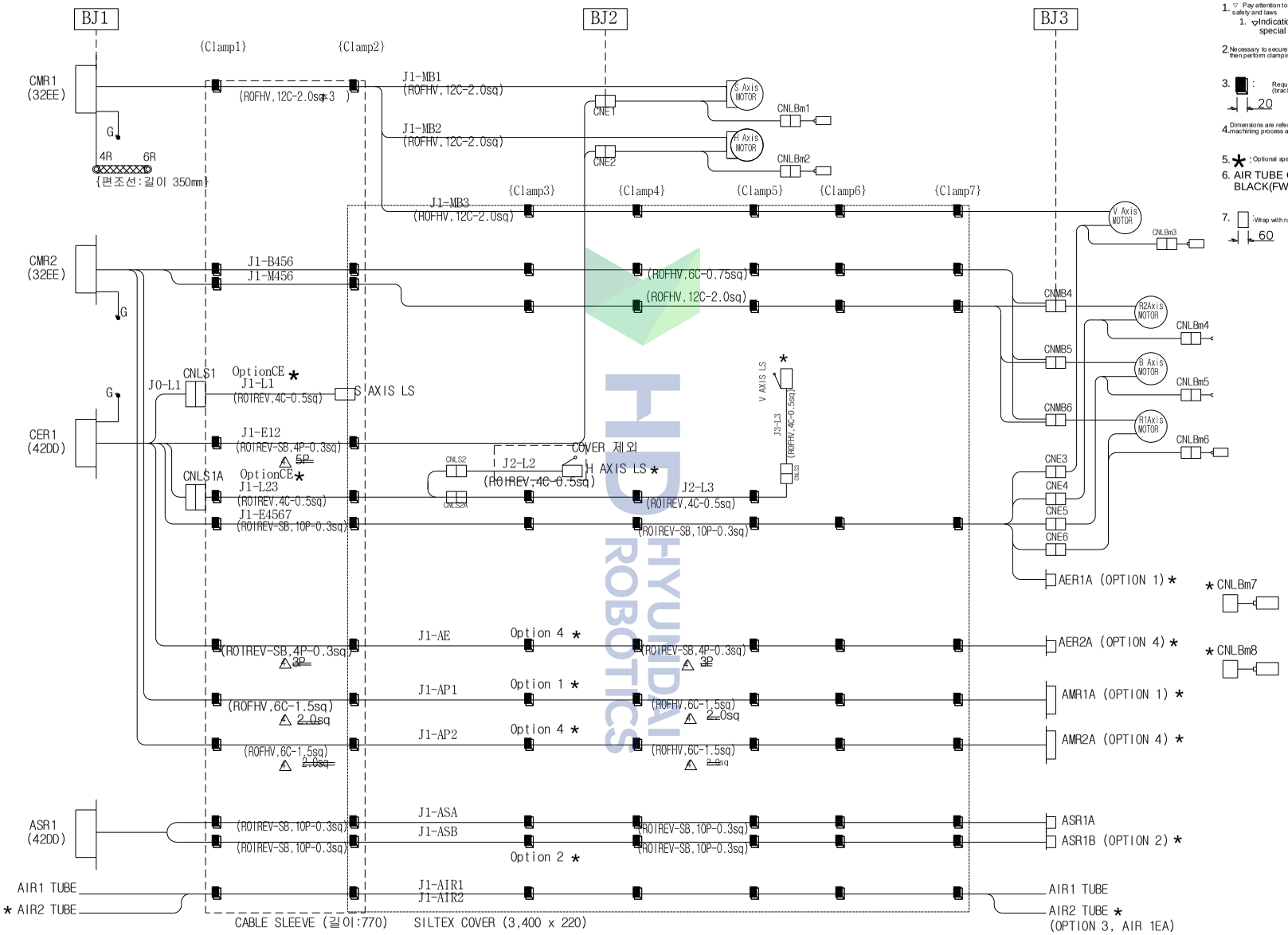


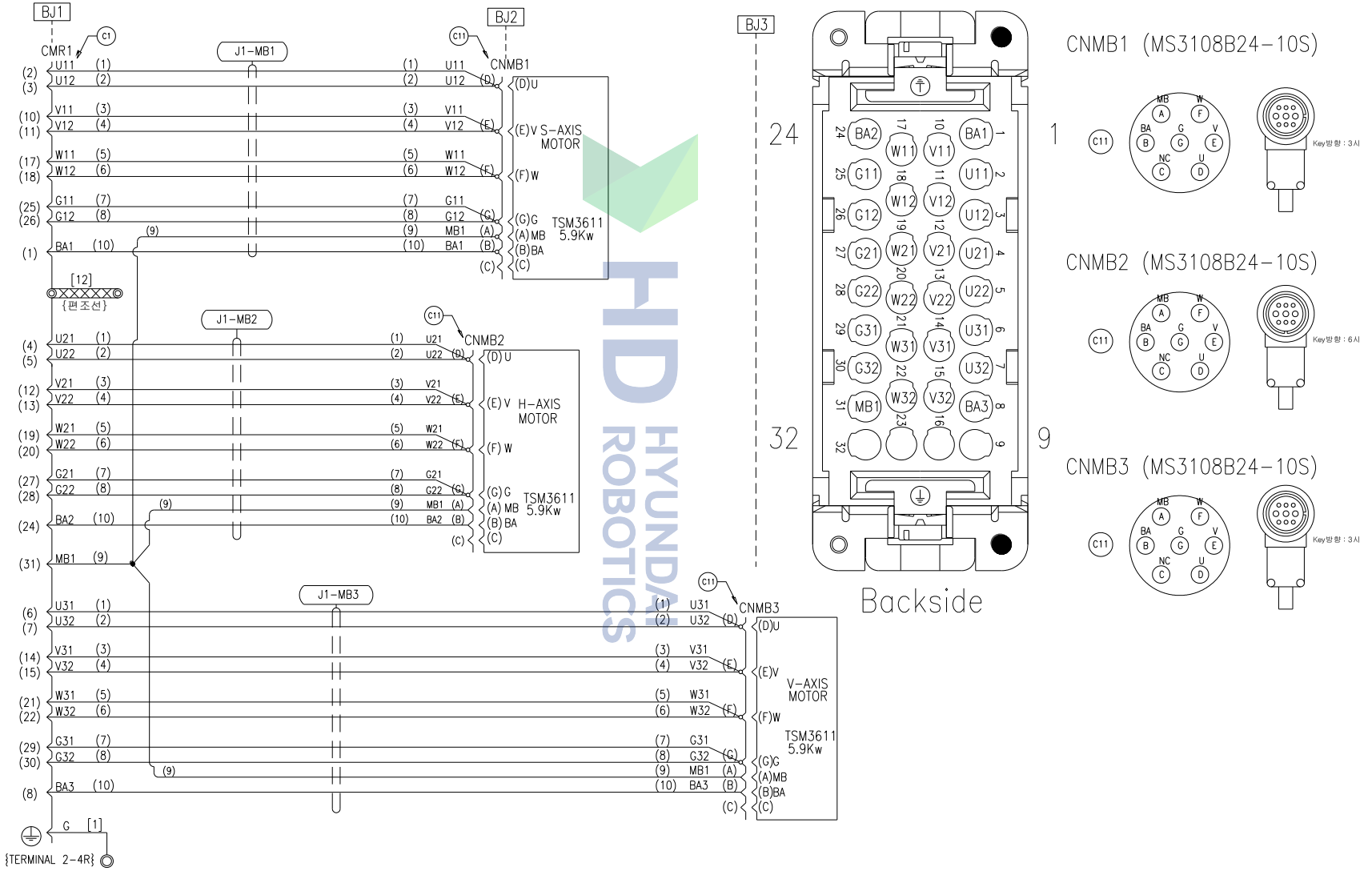
Figure 10.1 Placement of Parts inside the Manipulator

Internal Wiring Diagram of HS220 Series Robots

PAGE NO	CONTENTS
1	CABLE BLOCK DIAGRAM
2	MOTOR POWER CABLE CONNECTION FOR S,H,V AXIS
3	MOTOR POWER CABLE CONNECTION FOR R2,B,R1 AXIS
4	MOTOR ENCODER CABLE CONNECTION FOR S,H AXIS
5	MOTOR ENCODER CABLE CONNECTION FOR V,R2,B,R1 AXIS
6	ADD AXIS CABLE CONNECTION
7	USER APPLICATION CONNECTION

HYUNDAI ROBOTICS

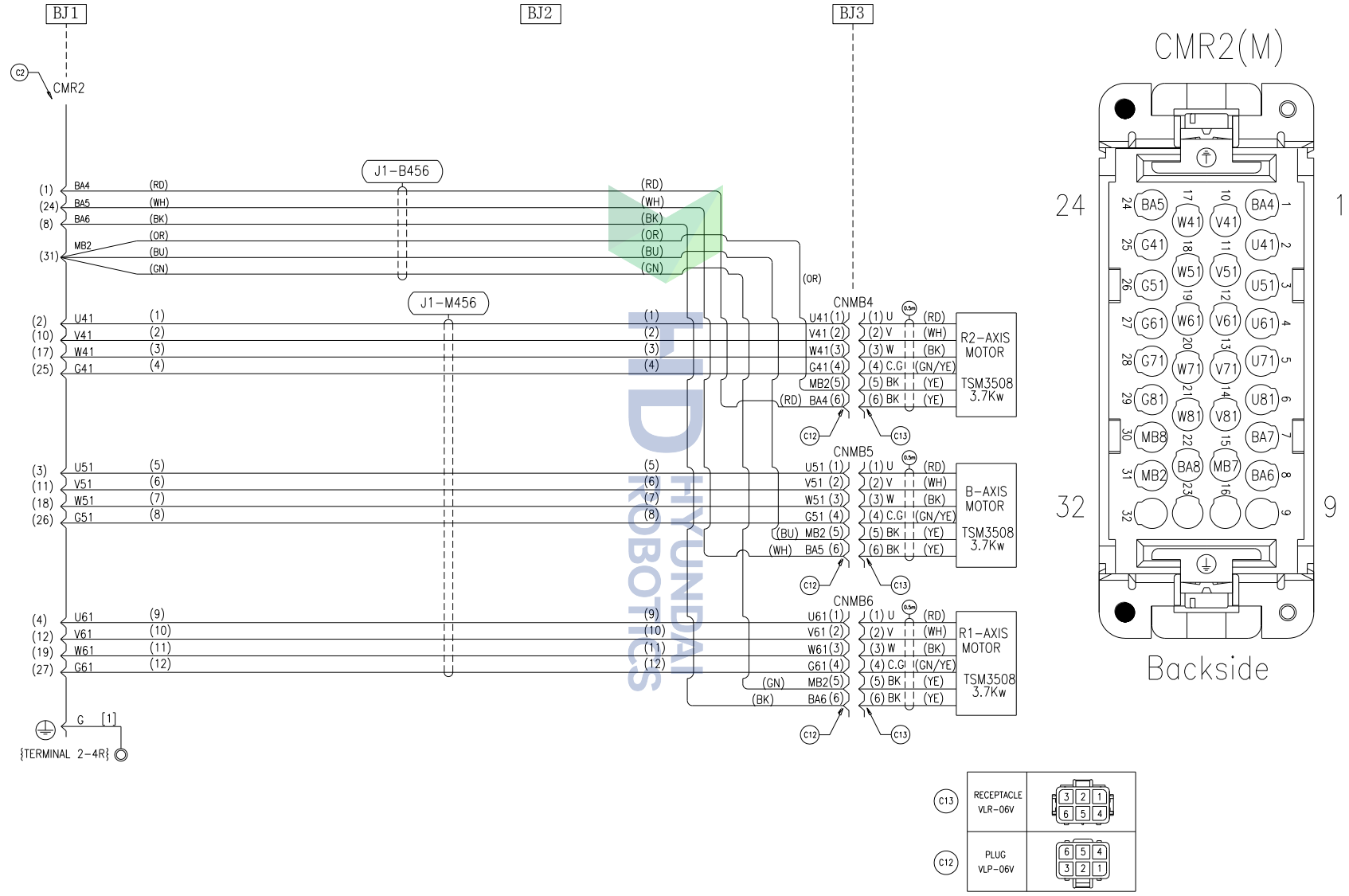

BJ1
BJ2
BJ3
{Clamp1}
{Clamp2}
{Clamp3}
{Clamp4}
{Clamp5}
{Clamp6}
{Clamp7}
CMR1 (32EE)
CMR2 (32EE)
CER1 (42DD)
ASR1 (42DD)
G
4R
6R
{편조선 : 길이 350mm}
(ROFHV,12C-2.0sq*3)
J1-MB1 (ROFHV,12C-2.0sq)
J1-MB2 (ROFHV,12C-2.0sq)
J1-MB3 (ROFHV,12C-2.0sq)
CNE1
CNE2
S Axis MOTOR
H Axis MOTOR
CNLBm1
CNLBm2
J1-B456
J1-M456
(ROFHV,6C-0.75sq)
(ROFHV,12C-2.0sq)
V Axis MOTOR
CNLBm3
CNMB4
CNMB5
CNMB6
R2Axis MOTOR
R1Axis MOTOR
CNLBm4
CNLBm5
CNLBm6
J0-L1
CNLS1
OptionCE *
J1-L1
(ROTREV,4C-0.5sq)
S AXIS LS
J1-E12
(ROTREV-SB,4P-0.3sq)
5P
CNLS1A
OptionCE *
J1-L23
(ROTREV,4C-0.5sq)
J1-E4567
(ROTREV-SB,10P-0.3sq)
CNLS2
CNLS2A
J2-L2
(ROTREV,4C-0.5sq)
COVER 제외
H AXIS LS *
J2-L3
(ROTREV,4C-0.5sq)
V AXIS LS *
J3-L3
(ROFHV,4C-0.5sq)
CNLS3
CNE3
CNE4
CNE5
CNE6
AER1A (OPTION 1) *
J1-AE
Option 4 *
(ROTREV-SB,4P-0.3sq)
3P
AER2A (OPTION 4) *
J1-AP1
Option 1 *
(ROFHV,6C-1.5sq)
2.0sq
AMR1A (OPTION 1) *
J1-AP2
Option 4 *
AMR2A (OPTION 4) *
J1-ASA
J1-ASB
(ROTREV-SB,10P-0.3sq)
Option 2 *
ASR1A
ASR1B (OPTION 2) *
AIR1 TUBE
* AIR2 TUBE
J1-AIR1
J1-AIR2
CABLE SLEEVE (길이:770)
SILTEX COVER (3,400 x 220)
AIR1 TUBE
AIR2 TUBE *
(OPTION 3, AIR 1EA)
* CNLBm7
* CNLBm8
NOTE)
1. ▽ Pay attention to the compatibility with safety and laws
1. ▽Indication safety/compliance special characteristcs
2. Necessary to secure a supply of necessary parts and then perform clamping and supply them.
3. : Required to mark the clamped sections (brackets or cable ties) with white tape.
20
4. Dimensions are reference dimensions given after the machining process and clamping work.
5. * : Optional specification
6. AIR TUBE COLOR BLACK(FWU-4-12X8 : NITTA MOORE)
7. : Wrap with rubber
60
TITLE : CABLE BLOCK DIAGRAM
HYUNDAI ROBOTICS
A3 (420x297mm)



TITLE : MOTOR POWER CABLE CONNECTION FOR S,H,V AXIS

HYUNDAI ROBOTICS

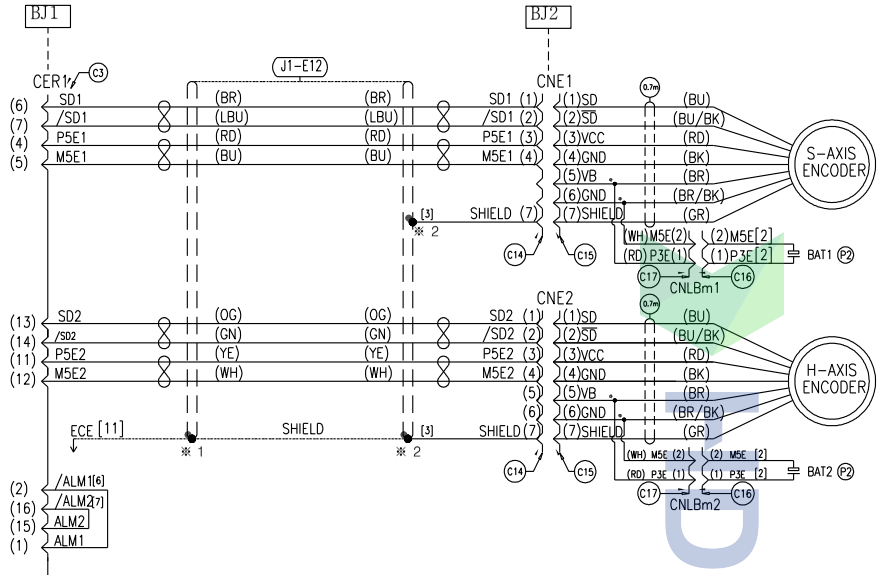
A3 (420x297mm)

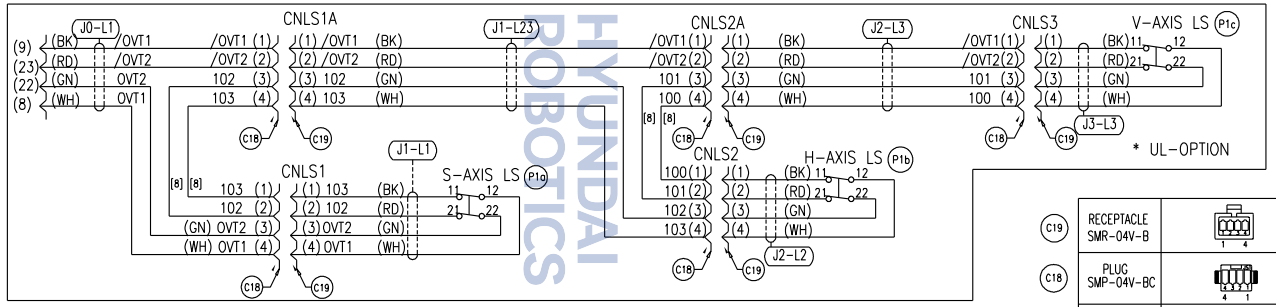


TITLE : MOTOR POWER CABLE CONNECTION FOR R2,B,R1 AXIS

HYUNDAI ROBOTICS

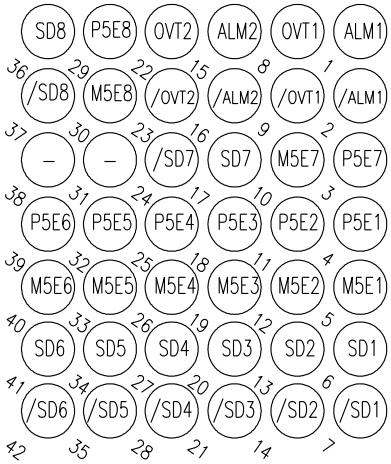
A3 (420x297mm)





CER1(Male)

Backside



LIMIT SWITCH TYPE

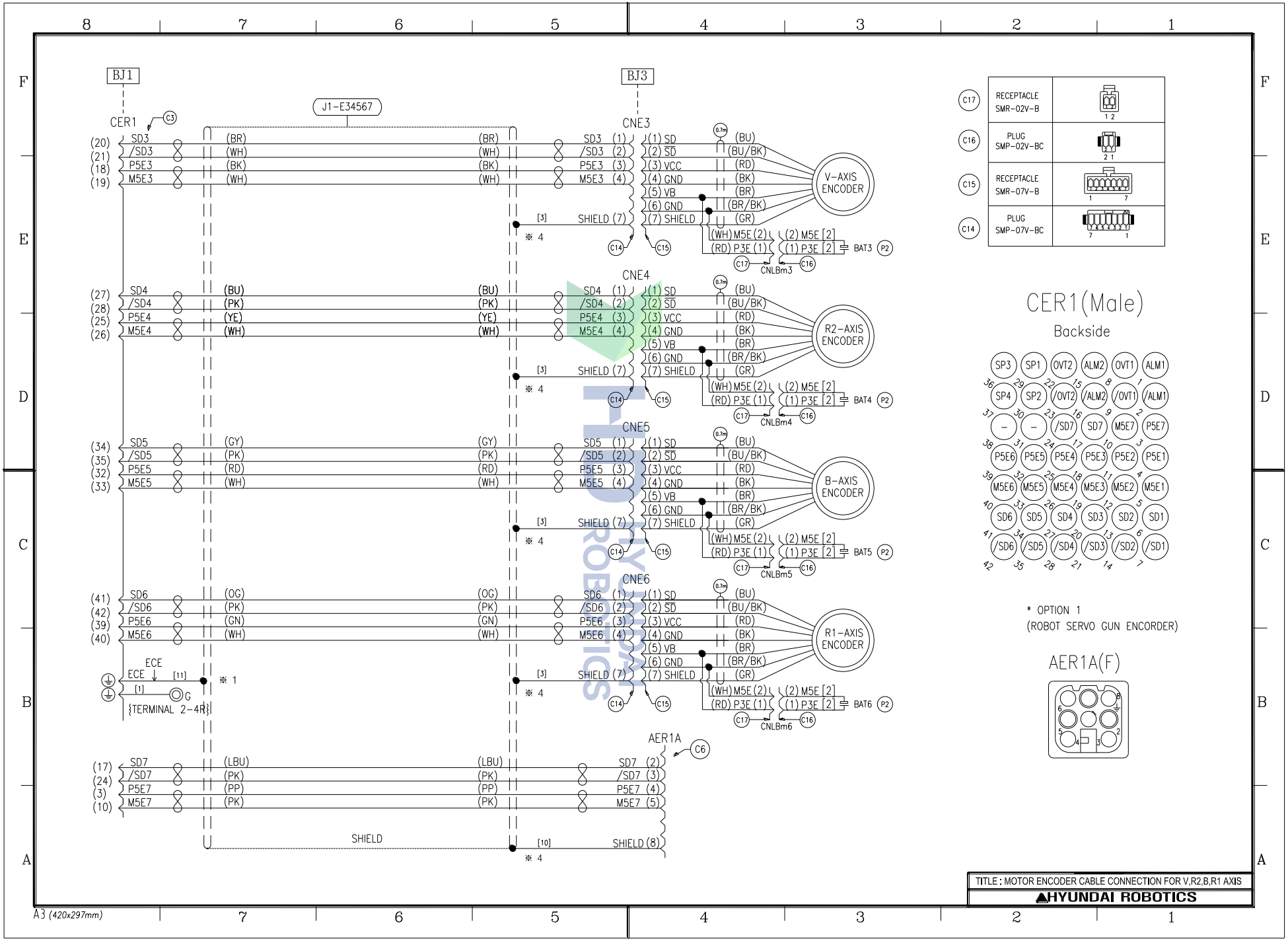
USE	TYPE	CABLE 방향
S-AXIS (P1a)	D4N-5B22	
H-AXIS (P1b)	D4N-5B32	
V-AXIS (P1c)	D4N-5B32	

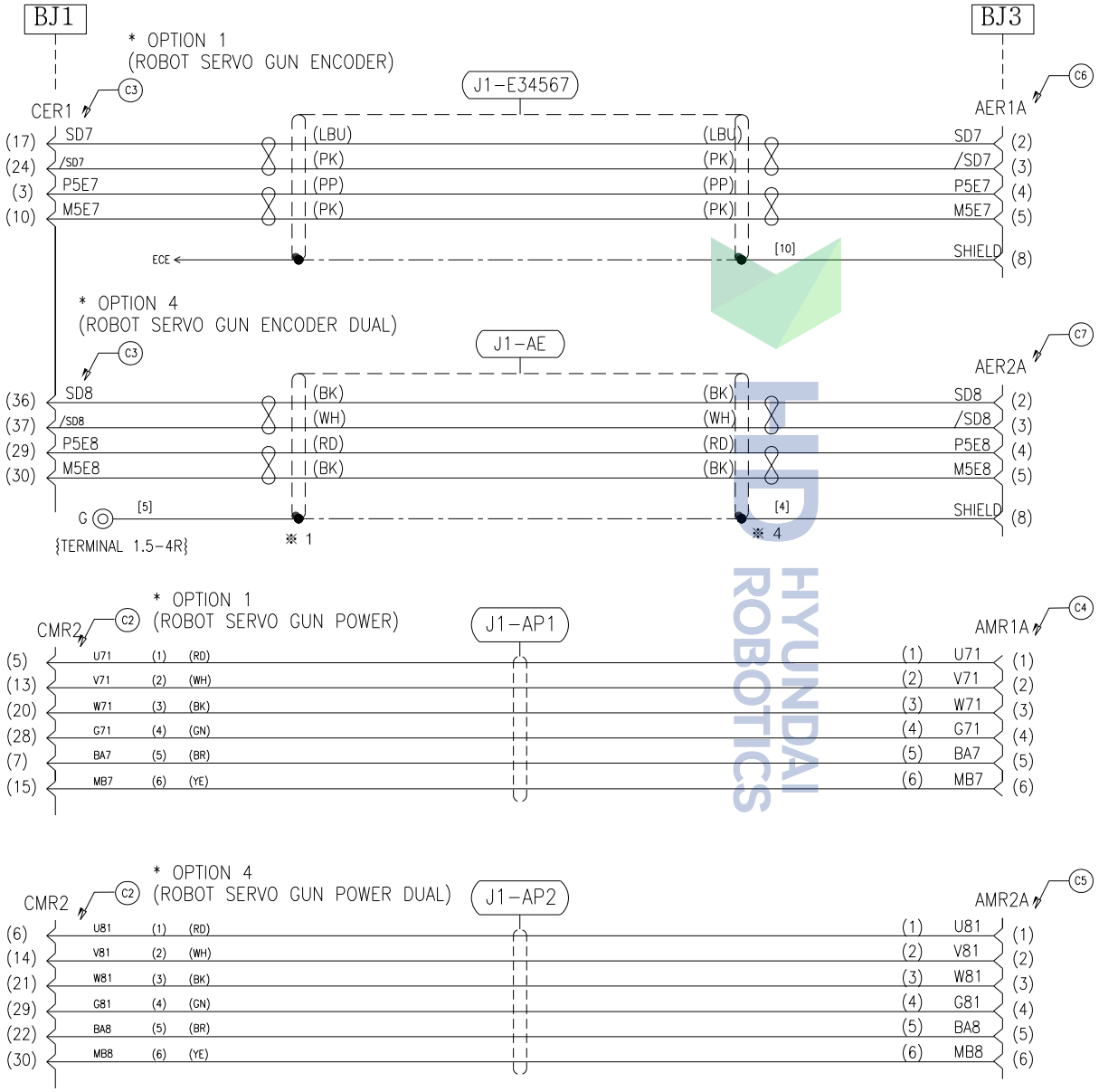
C19	RECEPTACLE SMR-04V-B	
C18	PLUG SMP-04V-BC	
C17	RECEPTACLE SMR-02V-B	
C16	PLUG SMP-02V-BC	
C15	RECEPTACLE SMR-07V-B	
C14	PLUG SMP-07V-BC	

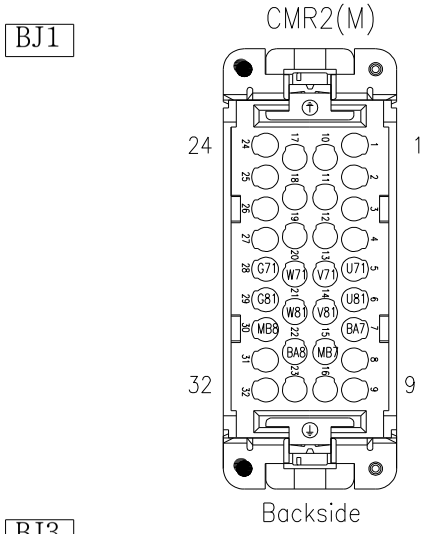
TITLE : MOTOR ENCODER CABLE CONNECTION FOR S,H AXIS

HYUNDAI ROBOTICS

A3 (420x297mm)


BJ1
BJ3
CER1
C3
J1-E34567
CNE3
CNE4
CNE5
CNE6
AER1A
C6
V-AXIS ENCODER
R2-AXIS ENCODER
B-AXIS ENCODER
R1-AXIS ENCODER
BAT3 P2
BAT4 P2
BAT5 P2
BAT6 P2
CNLBm3
CNLBm4
CNLBm5
CNLBm6
ECE
{TERMINAL 2-4R}
SHIELD
※ 1
※ 4
C14
C15
C16
C17
RECEPTACLE SMR-02V-B
PLUG SMP-02V-BC
RECEPTACLE SMR-07V-B
PLUG SMP-07V-BC
CER1(Male)
Backside
SP3 SP1 OVT2 ALM2 OVT1 ALM1
SP4 SP2 /OVT2 /ALM2 /OVT1 /ALM1
– – /SD7 SD7 M5E7 P5E7
P5E6 P5E5 P5E4 P5E3 P5E2 P5E1
M5E6 M5E5 M5E4 M5E3 M5E2 M5E1
SD6 SD5 SD4 SD3 SD2 SD1
/SD6 /SD5 /SD4 /SD3 /SD2 /SD1
* OPTION 1
(ROBOT SERVO GUN ENCORDER)
AER1A(F)
TITLE : MOTOR ENCODER CABLE CONNECTION FOR V,R2,B,R1 AXIS
HYUNDAI ROBOTICS
A3 (420x297mm)





TITLE : ADD AXIS CABLE CONNECTION

HYUNDAI ROBOTICS

A3 (420x297mm)

TITLE : USER APPLICATION CONNECTION

HYUNDAI ROBOTICS

A3 (420x297mm)

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