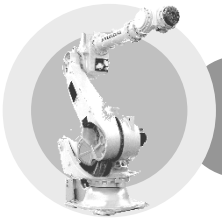
HYUNDAI ROBOTICS

Warning

INSTALLATION SHOULD ONLY BE PERFORMED BY QUALIFIED INSTALLATION PERSONNEL AND MUST CONFORM TO ALL NATIONAL AND LOCAL CODES

Hyundai Robot

HS210E230511MMEN3



Manipulator Maintenance Manual

HS210E

HD HYUNDAI ROBOTICS

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1 Safety

1.1. Introduction

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

This manual describes safety precautions for robot manipulator and controller, in complies with the safety regulation of EU Machinery Directive 98/37/EC(2006/42/EC) and US OSHA. And the robot manipulator and controller is manufactured to comply with the safety standards EN ISO 10218-1:2006 and ANSI/RIA R15.06-1999.

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

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

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

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

In high-risk areas concerning robot systems in which robots, tools, and accessories operate, there must be a method of protection to stop the workers or objects from entering the area according to ANSI/RIA R15.06-1999.

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

Applicable areas

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

Major application is

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

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

Disable environment

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

1.2. Relevant Safety Regulations

The robot is designed as per ISO 10218-1:2006 safety standards for industrial robots, and furthermore in comply with ANSI/RIA 15.06-1999 regulations.

1.3. Safety Training

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

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

1.4. Safety Related Nameplate

1.4.1. Safety Marking

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

Table 1-1 Safety marking

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

1.4.2. Safety Nameplate

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

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

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

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

1.5. Definition of Safety Functions

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

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

Safety Stop Function - EN ISO 10218-1:2006

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

Speed Limitation Function - EN ISO 10218-1:2006

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

Restricting working Envelope - ANSI/RIA R15.06-1999

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

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

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

1.6. Installation

1.6.1. Safety Fence

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

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

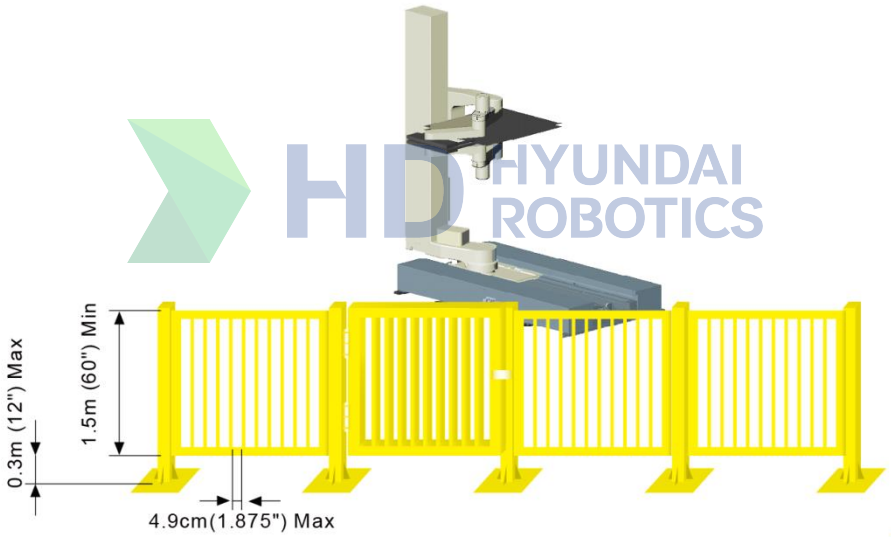

Figure 1.1 Recommended size for safety net and entrance gate (slot type entrance gate)

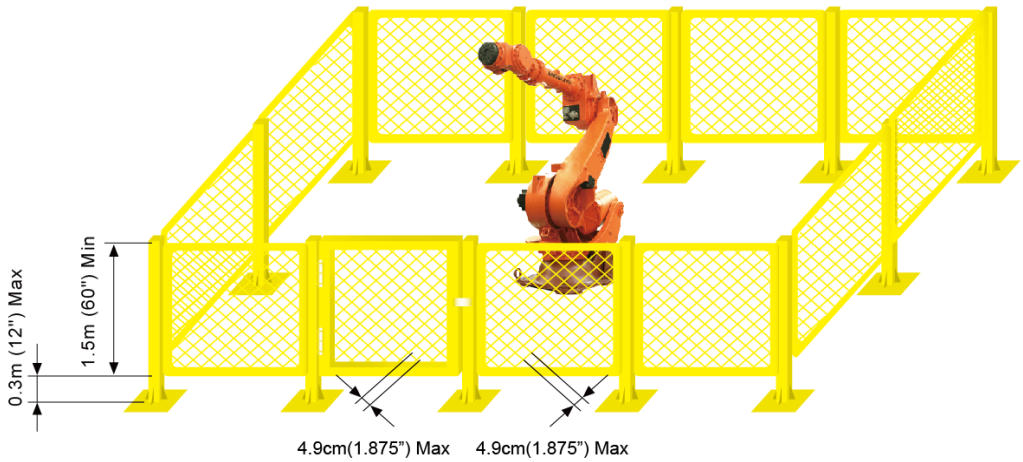

Figure 1.2 Recommended size for safety net and entrance gate (square type entrance gate)

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

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

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

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

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

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

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

1.6.2. Placement of Robot & Peripheral Equipment

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

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

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

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

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

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

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

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

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

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

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

movement of the robot.

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

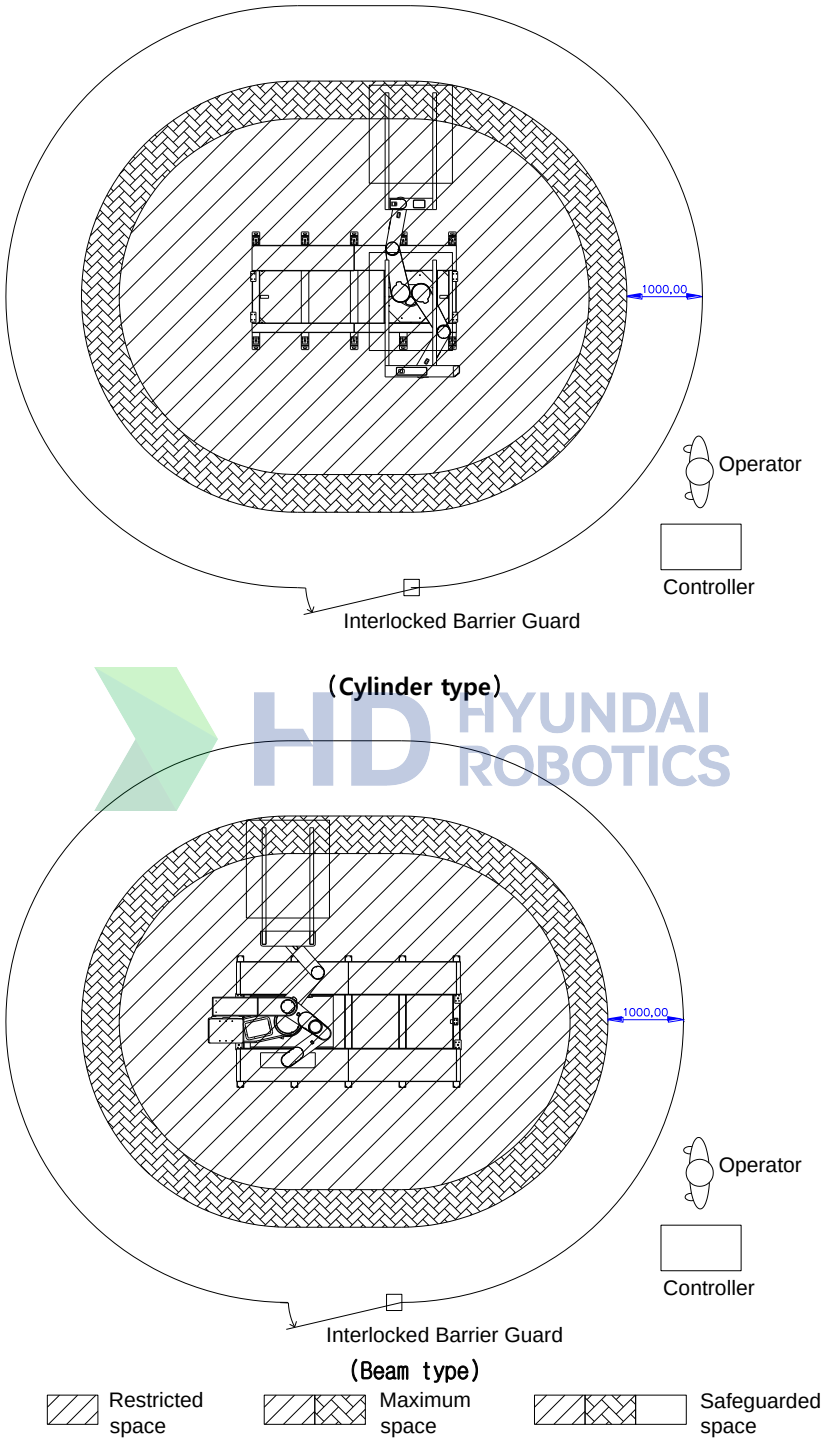

Figure 1.3 Arrangement of LCD robot peripheral devices and workers

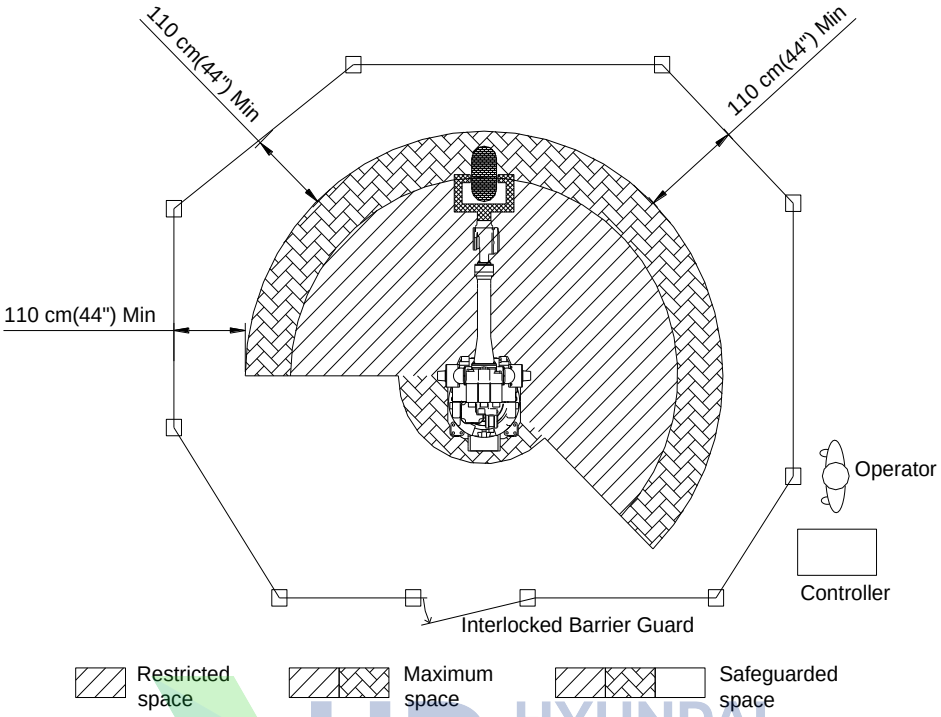

Figure 1.4 Arrangement of general robot peripheral devices and workers

1.6.3. Installing the Robot

Please install the robot in accordance with following method surely.

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

General Safety Precautions

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

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

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

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

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

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

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

Technical Safety Precautions

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1.6.4. Space for Robot Installation

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

1.7. Safety Operation for Robot Handling

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

1.7.1. Safety Precautions for Robot Handling

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

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

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

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

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

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

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

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

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

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

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

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


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

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


(14) Instructions for any abnormal operations.

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

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

(16) Instructions when the robot stops

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

Table 1-2 State of Robot Stop

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

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

circumstances.

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

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

1.7.2. Safety Precautions for Operating Test

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

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

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

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

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

1.7.3. Safety Precautions for Automatic Operation

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

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

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

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

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

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

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

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

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

1.8. Safety Precautions for Access to Safety Fence

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

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

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

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

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

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

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

(4) Do not wear gloves when handling controller.

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

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

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

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

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

(10) Follow the predetermined working procedure.

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

1.9. Safety Precautions for Maintenance and Repair

1.9.1. Safety Precautions for Controller Maintenance and Repair

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

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

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

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

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

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

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

(7) If sufficient illuminance is not secured when you perform maintenance and inspection inside the controller, you should use external lights.

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

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

1.9.2. Safety Precautions for Robot System & Manipulator Maintenance

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

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

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

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

(4) Make sure that the Arm is fixed and immovable before maintenance and repair since dropping or moving of the robot's Arm may cause a danger during maintenance and repair. (Refer to the 『Robot manipulator maintenance manual』.)

1.9.3. Necessary Actions after Maintenance and Repair

Please install the robot in accordance with following method surely.

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

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

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

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

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

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

(7) Operate the manipulator at low speed.

1.10. Safety Functions

1.10.1. Operating a Safety Circuit

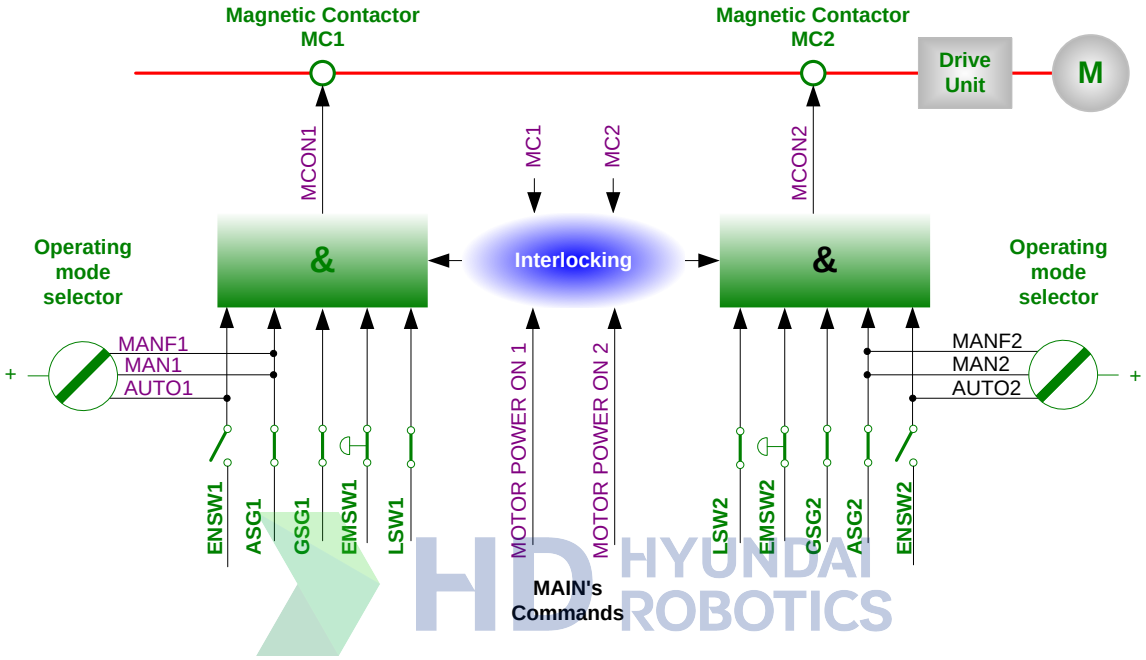

Figure 1.5 Configuration for safety chain

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

The safety control circuit of operation is based on dual safety electric circuit in which the controller and MOTOR ON mode are operated interactively. In order to be in MOTOR ON mode, the safety circuit consisted of several switches must be all connected. MOTOR ON mode indicates that drive power is supplied to the motors. If one of the contactors is disconnected, the robot will always return to MOTOR OFF mode.

MOTOR OFF mode indicates that drive power is removed from the robot's motors and the brakes are applied. The status of the switches is displayed on the teach pendant. (Refer to the I/O monitoring screen of "SERVICE" menu, 『Operation manual』.)

Safety circuit

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

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

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

1.10.2. Emergency stop

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

Status of Emergency stop

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

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

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

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

Above the control and teach pendant console.

(2) Emergency stop of external system

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

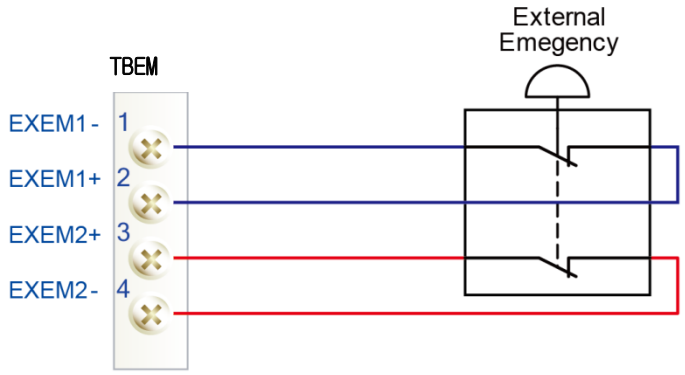

Figure 1.6 Connection with external emergency halt switch through system board terminal block TBEM

1.10.3. Operating Speed

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

1.10.4. Connecting the Safety Devices

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

1.10.5. Restricting the working Envelope

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

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

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

1.10.6. Monitoring Function

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

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

1.11. Safety Related to End Effectors

1.11.1. Gripper

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

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

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

1.11.2. Tool / Workpiece

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

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

1.11.3. Pneumatic and Hydraulic Systems

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

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

1.12. Liabilities

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

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

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

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

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

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

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

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2 Specifications

2.1. Robot Machinery Part

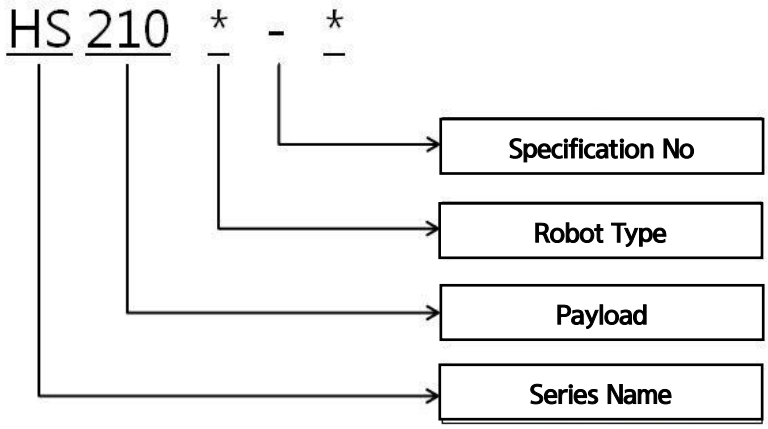

Figure 2.1 Robot Machinery Part

2.2. Location of Robot Identification Plate

The model name, serial number, and manufacturing date of robot are written down in the name plate. Identification plate is located at the bottom of the main body (Left or right side) as shown in the following figure.

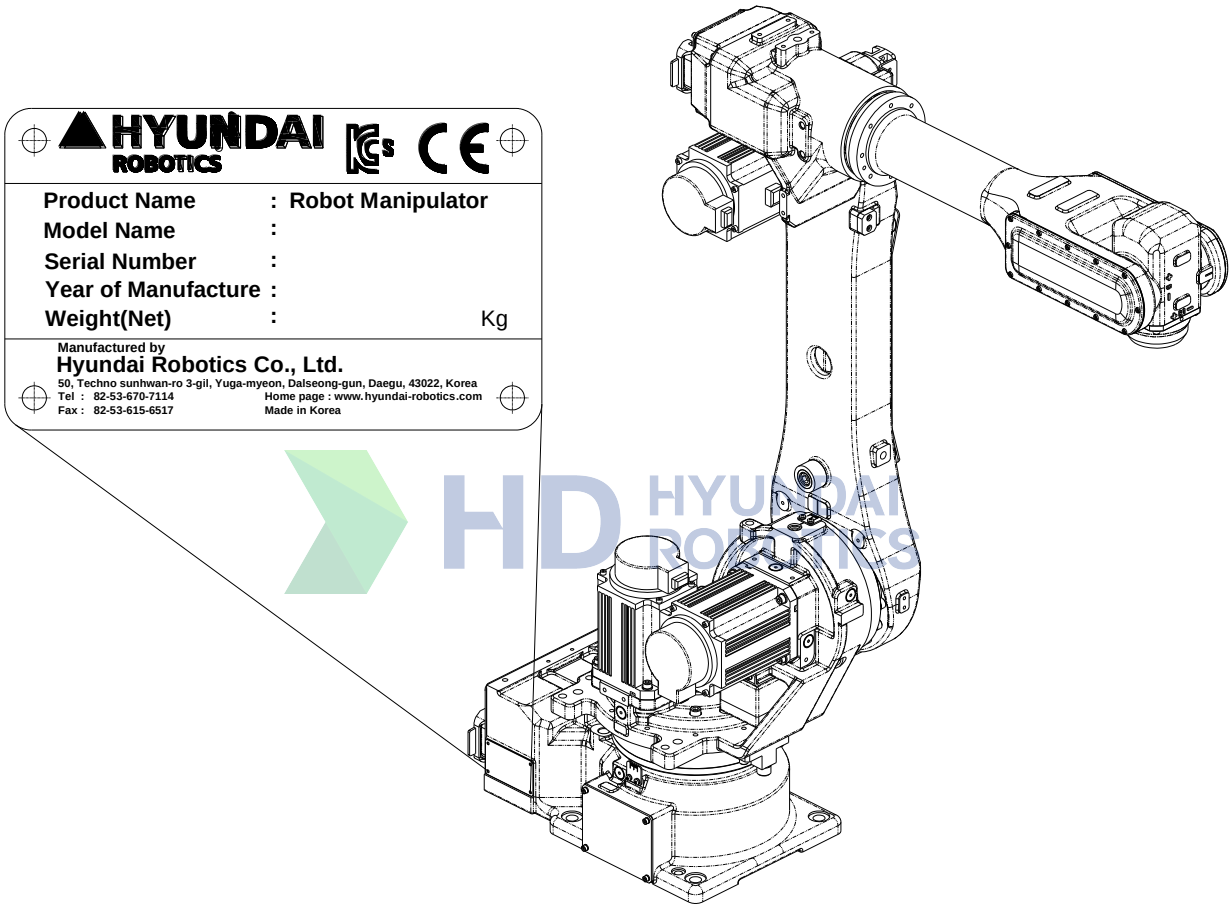

Figure 2.2 The location of identification plate

2.3. Basic specifications

Table 2-1 Basic Specification for Each Model

Item				Specification
Model name				HS210E
Payload				210kg
Structure				Articulated
Degree of freedom				6 (6-axes S, H, V, R2,B, R1)
Driving method				AC servo
Installation type				To be fixed on the floor (floor mount)
Maximum opertion range	Main axis	S	Swivel	±3.142 rad (±180°), ±3.107 rad (±178°) LS Option[1]
		H	Horizontal	+0.175 ~ 2.705 rad (+10° ~ 155°)
		V	Vertical	+1.396 ~ -1.309 rad (+80° ~ -75°)
		H/V	Interference	+0.262 ~ 2.967 rad (15° ~ 170°),
	Wrist axis	R2	Rotation 2	±3.665 rad (±210°)
		B	Bending	±2.182 rad (±125°)
		R1	Rotation 1	±3.665 rad (±210°)
Max. speed	Main axis	S	Swivel	2.094 rad/s (120°/s)
		H	Horizontal	1.833 rad/s (105°/s)
		V	Vertical	1.920 rad/s (110°/s)
	Wrist axis	R2	Rotation 2	2.269 rad/s (130°/s)
		B	Bending	2.269 rad/s (130°/s)
		R1	1	3.578 rad/s (205°/s)
Payload				2,059 N.m (210 kg)

[1] LS Option: Maximum operation angle when a limit switch for limitng the angle is attached.

Item			Specification
Wrist torque	R2	Rotation 2	1,334 N.m (136 kgf.m)
	B	Bending	1,334 N.m (136 kgf.m)
	R1	Rotation 1	706 N.m (72 kgf.m)
Positional repeatability			± 0.09 mm
Main body weight			970 kg
Installation environment	Ambient temperature		0 ~ 45℃ (273 ~ 318 K)
	Relative humidity		20 ~ 85 %RH
	Vibration		0.5G or below

2.4. External dimensions and operation area of the main body

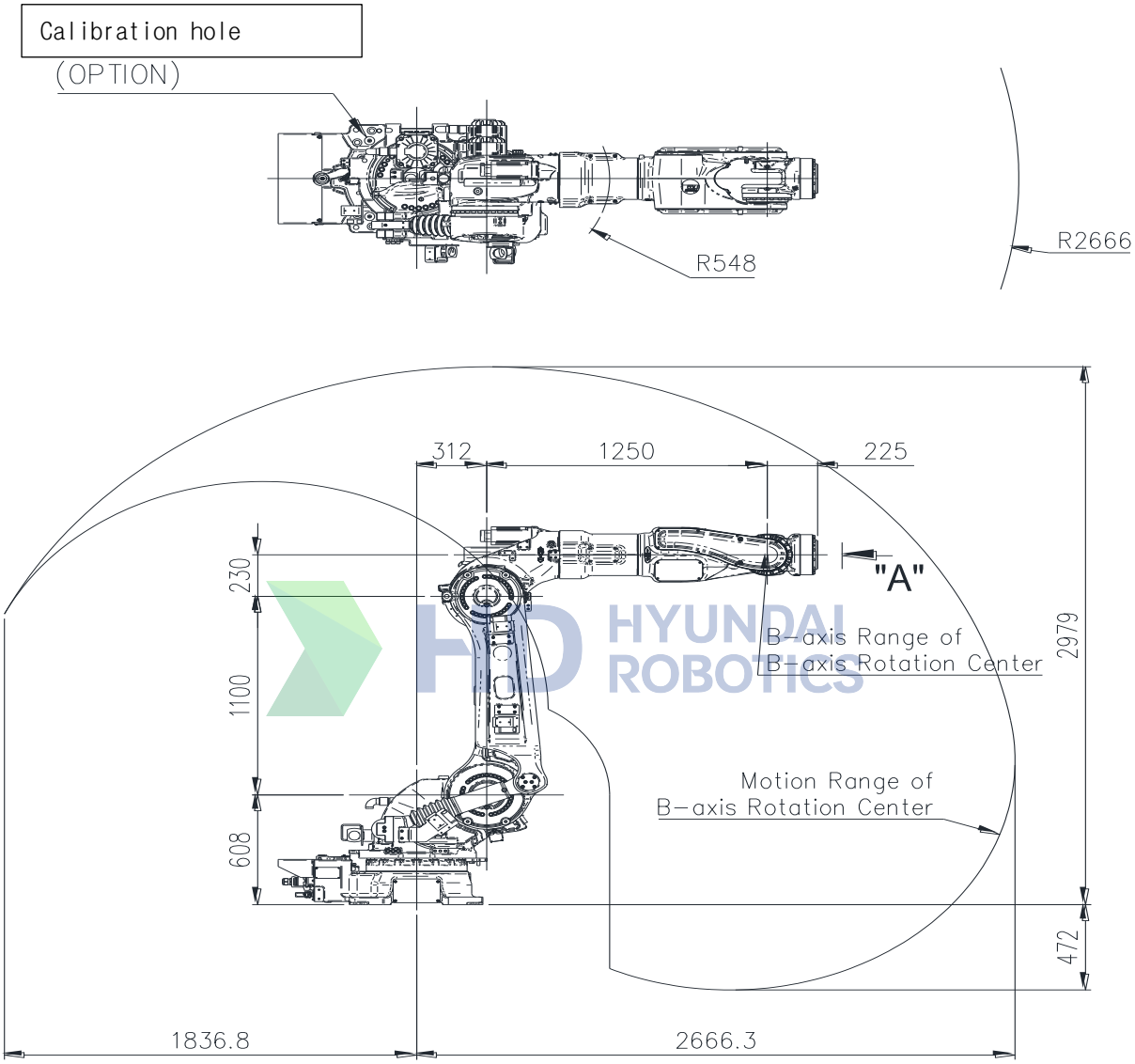

Figure 2.3 External dimensions and operation area of the robot's main body

2.5. Axis Identification

Table 2-2 Axis motion

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

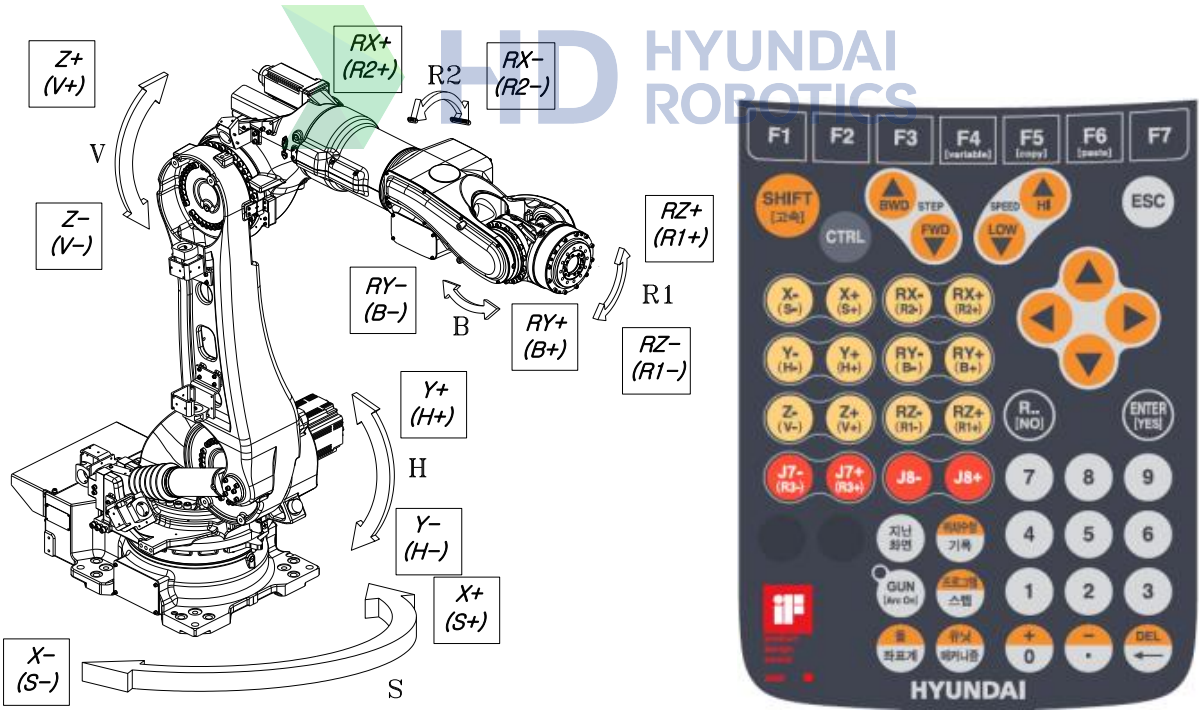

Figure 2.4 Robot Dimension and Axis

2.6. Detailed drawing of the wrist axis attachment surface

When attaching a working tool to the flange of the front end of the wrist axis, please use P.C.D. 125 bolts.

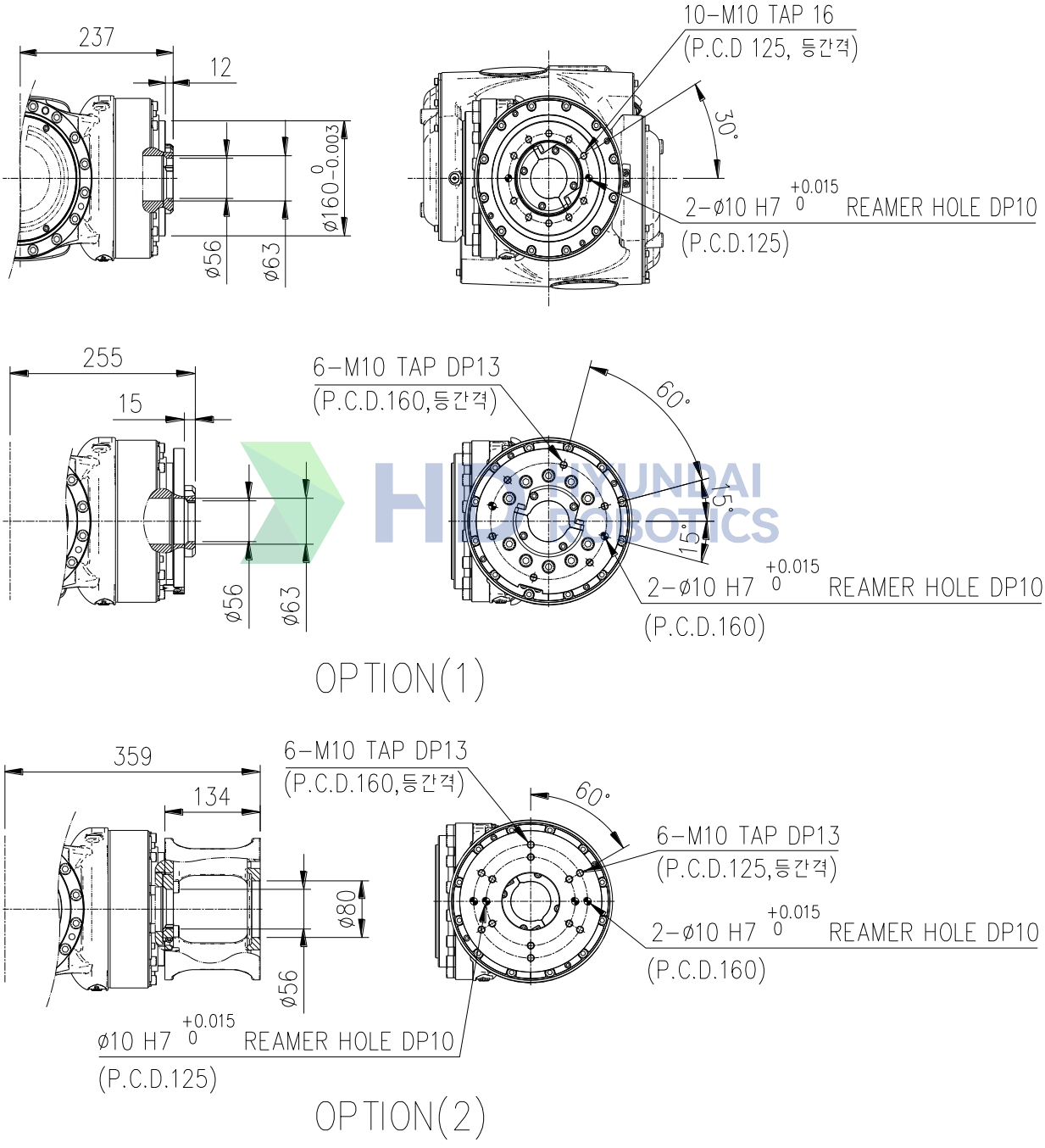

Figure 2.5 Detailed drawing of the wrist axis attachment surface

2.7. Application Wiring and Inspection Wiring Diagram

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

[Note] Maximum air pressure: 5bar (5.1 kgf/cm2 ,72.5 psi)

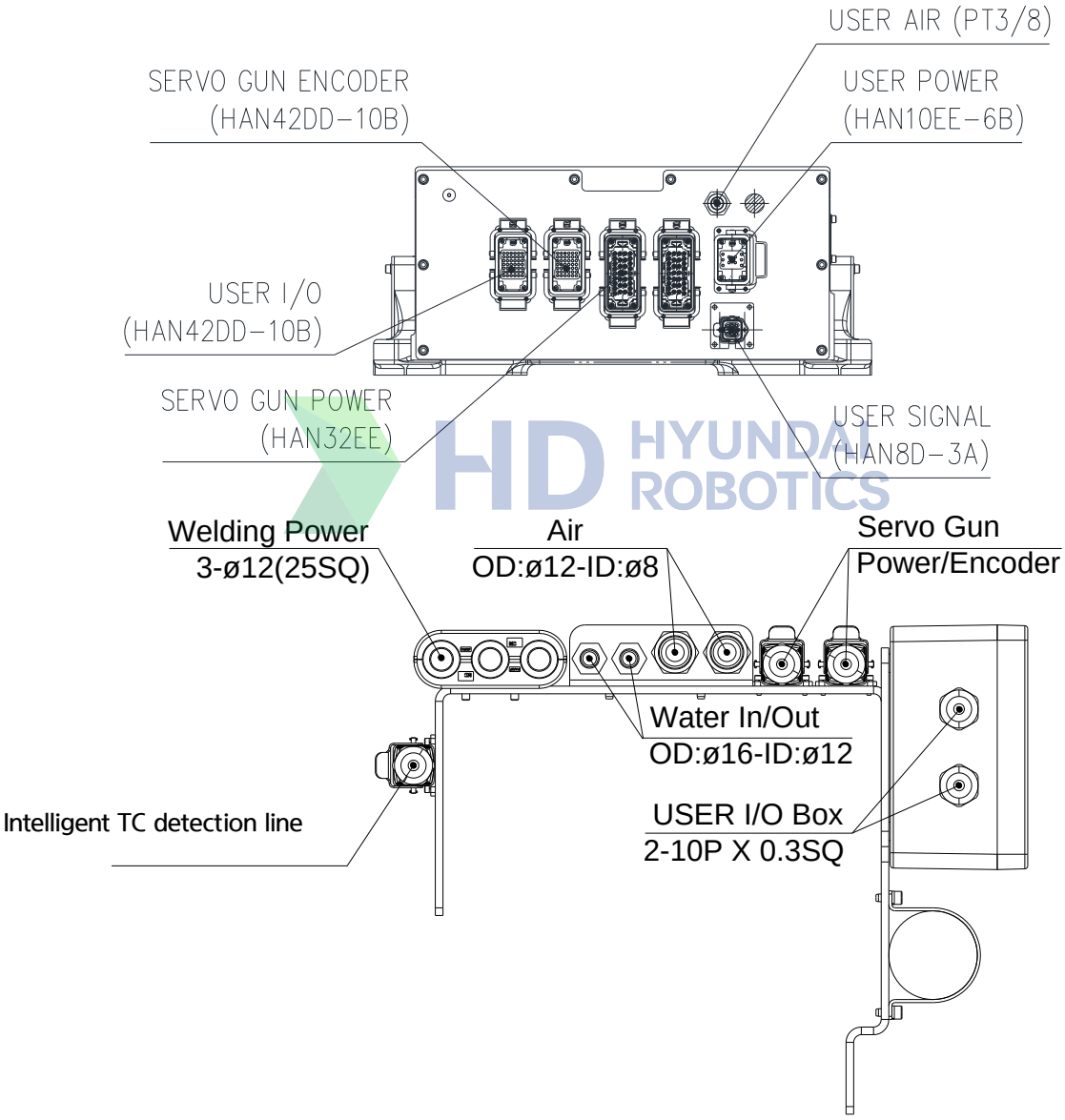

Figure 2.6 Application Wiring and Inspection Wiring

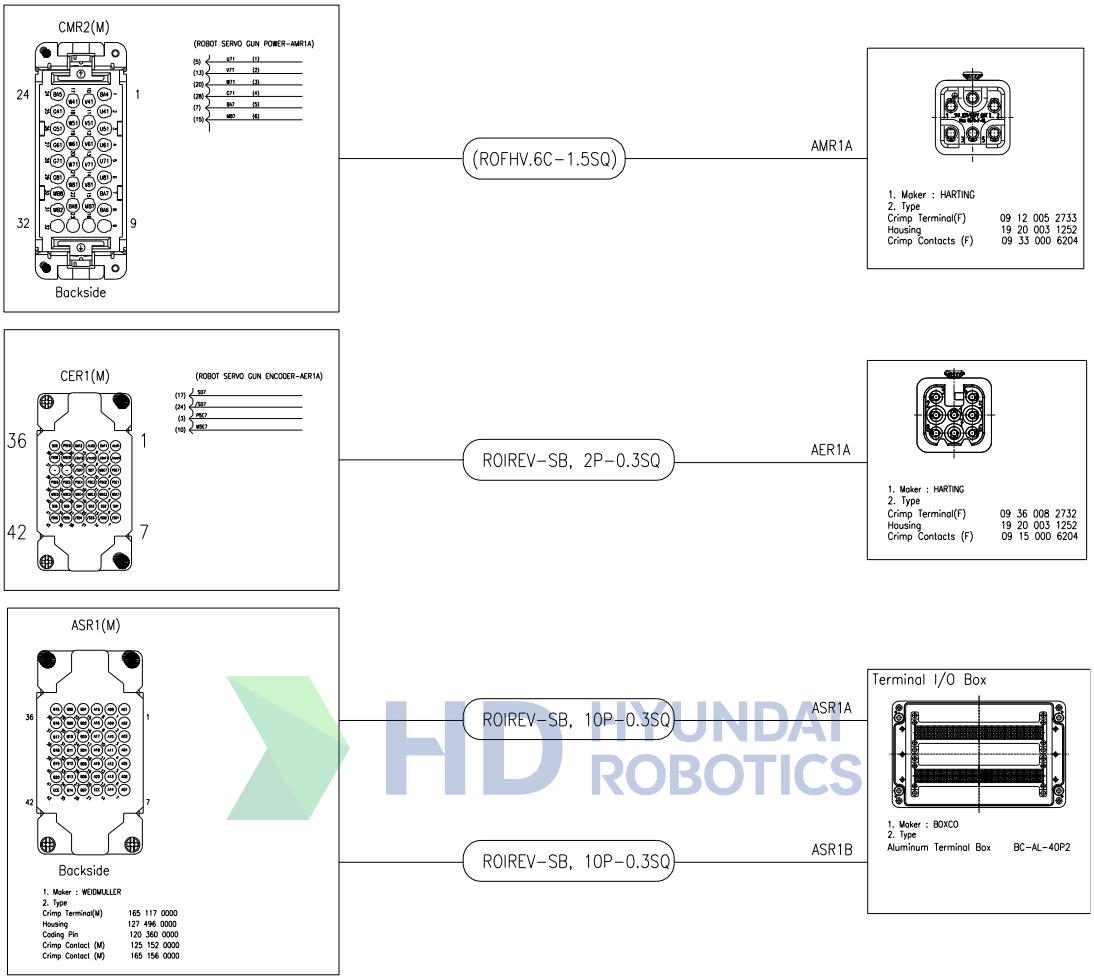

Figure 2.7 Details of the application connector

2.8. Restricting the Working Envelope

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

Limiting the motion range is useful when:

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

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

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

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

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

2.8.1. Axis 1(Axis S)

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

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3 Instructions

3.1. Robot Component Name

The following [Figure 3.1] show and name each component of the robot.

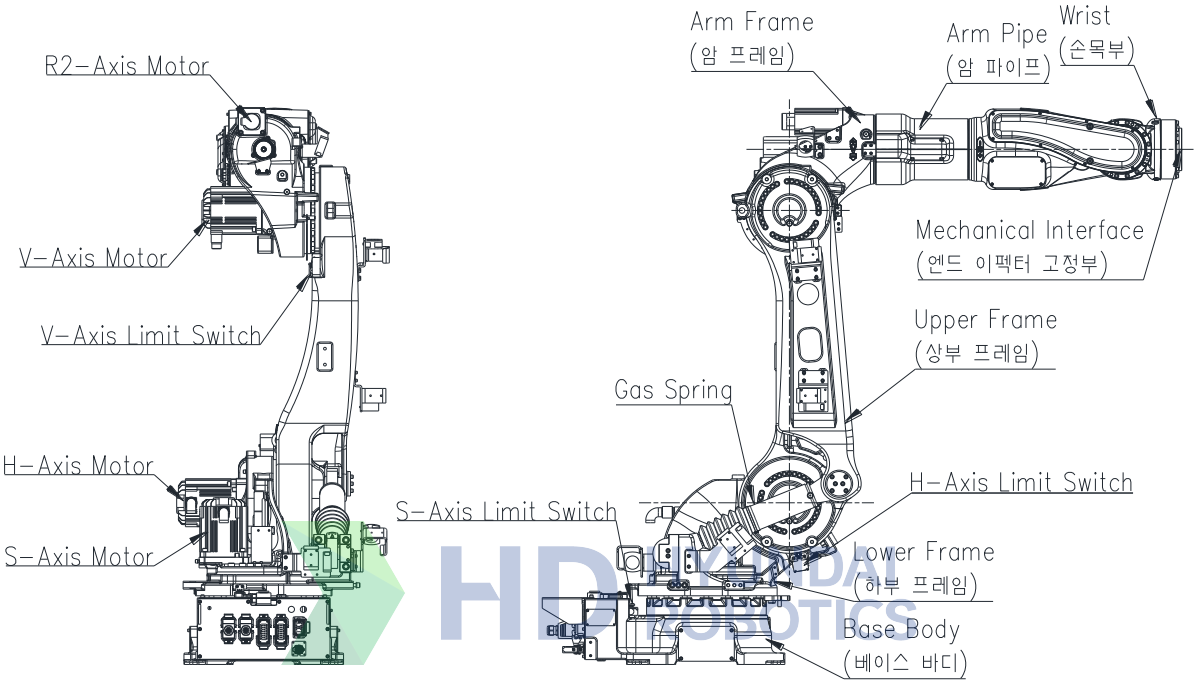


Figure 3.1 Name of Robot Components

[Note] The basic 3-axis limit switch is an option.

3.2. Location of Safety Nameplate

In order to prevent any accidents, safety marking plates such as [Figure 3.2] are attached to the robot. Do not remove or replace it unnecessarily.

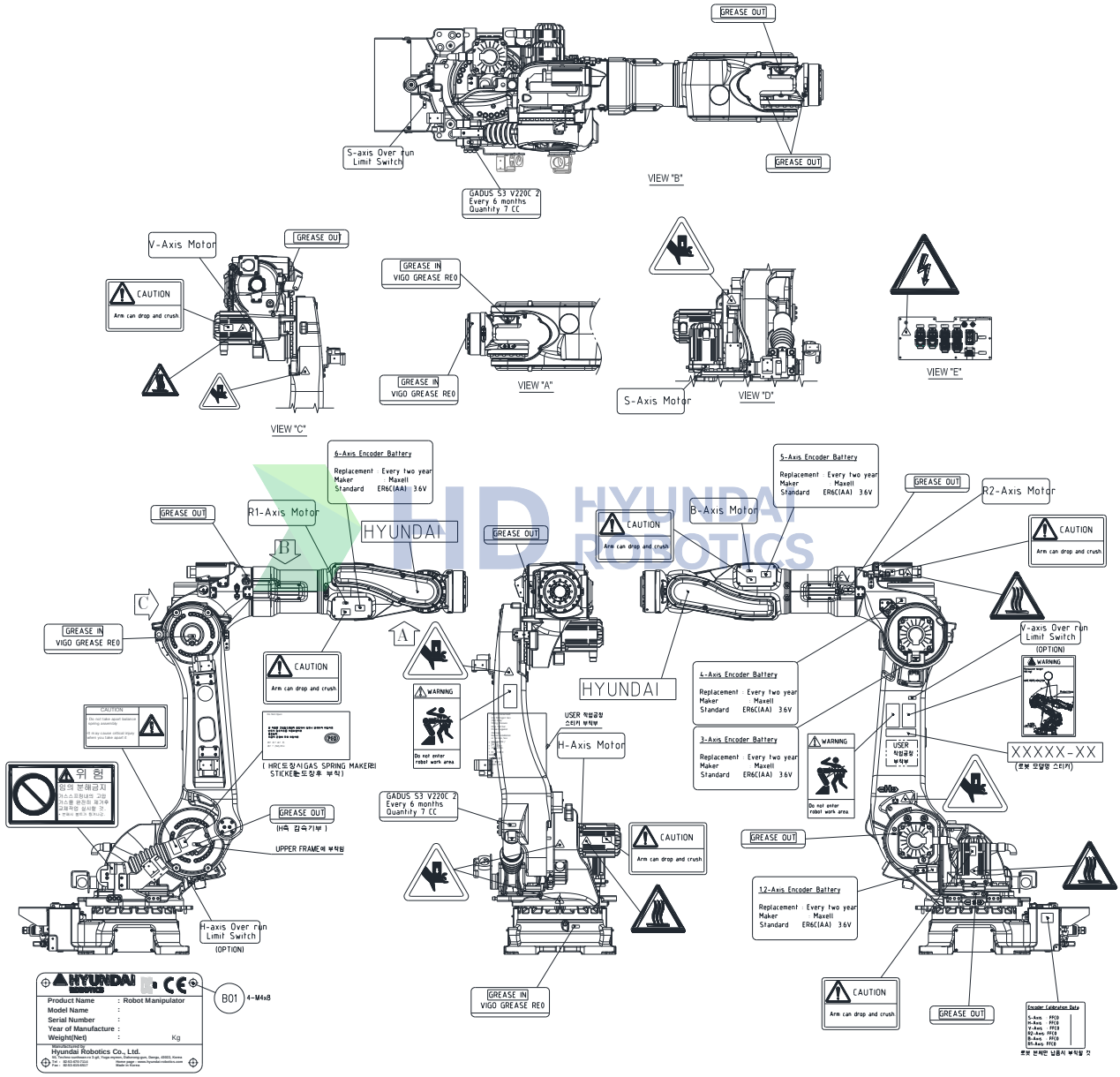


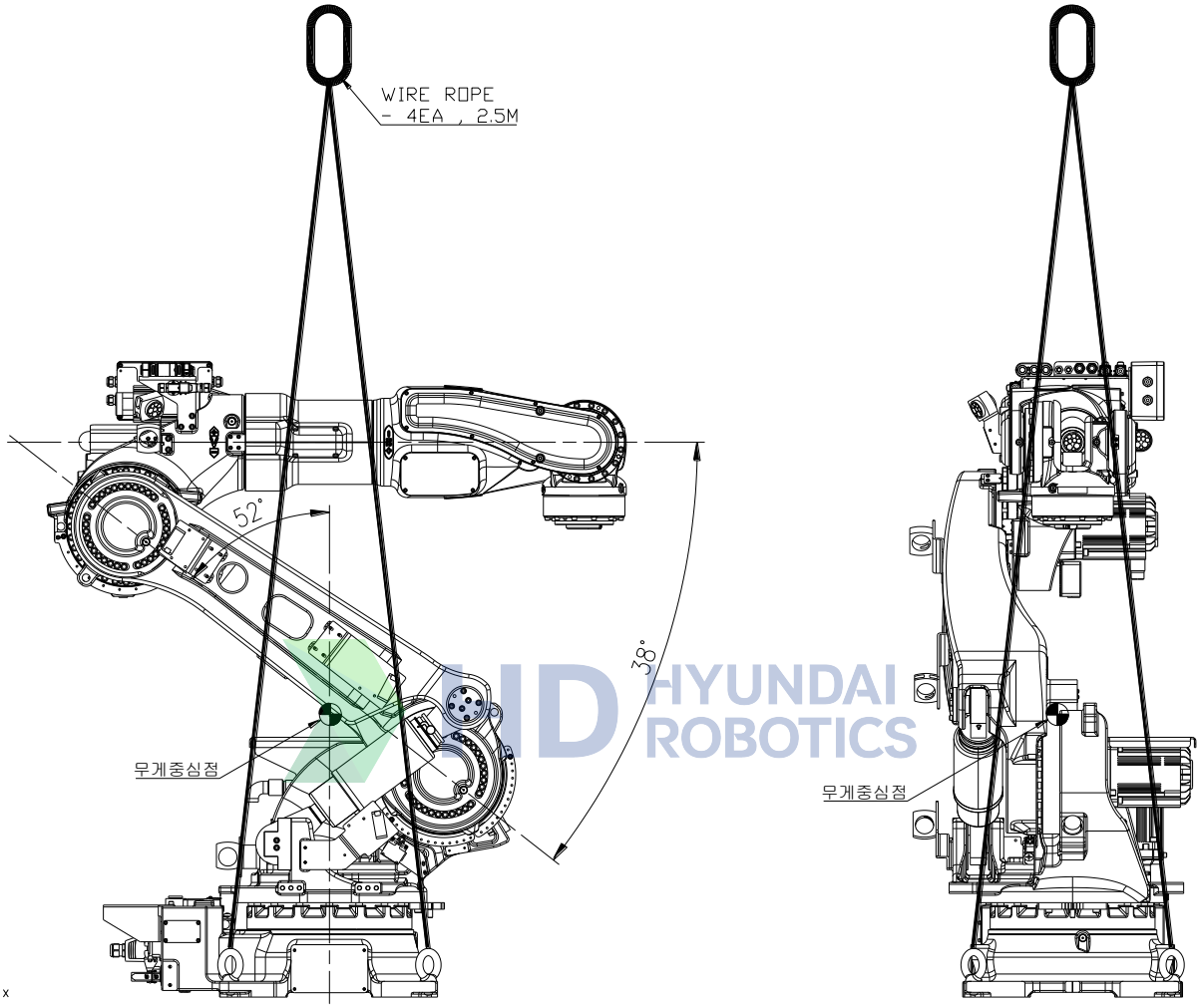
Figure 3.2 Location of Safety Nameplate (HS210E)

3.3. Transportation method

The robot can be transported by using a crane or a forklift. When moving the robot, change the robot's posture in a way suitable for each transportation situation as shown below and transport it using the eyebolts and designated transportation equipment.

- When moving or unloading the robot, please move it slowly and very carefully.
- When unloading the robot onto the floor, be careful not to cause a strong collision between the robot's lower installation surface and the floor surface.
- Never transport the robot by any other means than designated transportation equipment and methods.

3.3.1. Using Crane



S- Axis	0
H- Axis	142
V- Axis	-52
R2- Axis	0
B- Axis	-90
R1- Axis	0

Figure 3.3 Transporation method: Using a crane

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

- Never walk under the robot.
- Pose the robot as shown in the Figure..
- Install 4-M24 eye bolts to the base body.
- Fasten wire ropes (4 units) to the eye bolts (4 units).
- Minimum crane capacity: 2 tons. Minimum rope capacity: 1 ton/unit
- Attach a protective hose (50 cm) to the robot's main body to prevent damage.
- Observe the safety regulations when carrying out the lifting operation.
- Fix the ropes carefully to avoid damaging the robot's motors, connectors, and cables.
- Weight of the main body: 970 kg

3.3.2. Forklift use

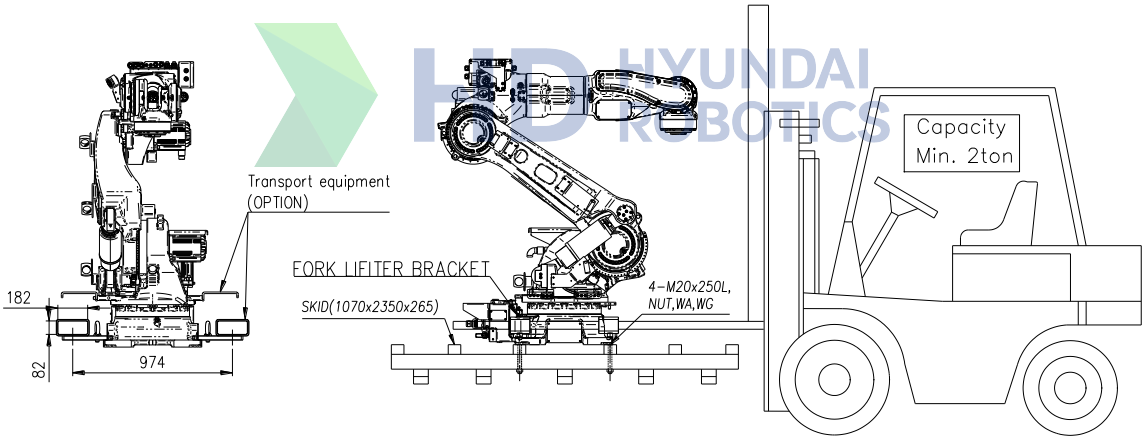
A forklift can be used to carry the main body of the robot.

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

- With reference to the pictures provided, use the standard position of each model.
- Fix the robot onto a pallet and insert the forklift fork into the pallet to carry it. The pallet should be strong enough to withstand the weight.
- Carry at a slow speed.
- Follow all safety regulations.

주의 사항

- Do not lean against the robot while carrying it.
- Make sure the robot does not collide with the floor while loading and unloading.
- Pay attention to the relevant safety rules while using the forklift truck.
- Check the fixing bolts to ensure that the robot is securely fixed to the palette before starting work.



S- Axis	0
H- Axis	142
V- Axis	-52
R2- Axis	0
B- Axis	-90
R1- Axis	0

Figure 3.4 How to Transport : Using forklift

3.4. Storage of the robot

To store the robot for non-use, position it as shown in [Figure 3.3].

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

3.5. How to Install

NOTE:
Before starting to unpack and install the robot, read the safety regulations and other instructions very carefully.

If the robot is to be used in an environment other than designated conditions of use, please contact the service center.

Warning:
The installation shall be made by qualified installation personnel and should conform to all national and local codes.

When unpacking the robot, check if it has been damaged during transporting or unpacking. In addition, strictly keep the following installation instructions because installation method and foundation are very important to maintain a good robot performance.

3.5.1. Operating Conditions

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

3.5.2. Installation the Robot Manipulator

When it comes to the rigidity of the foundation floor where the robot will be installed, the floor should be constructed with concrete more than 300 mm thick to minimize the dynamic influence of the robot. When installing the robot, repair uneven spots, cracks, and others on the floor and fix the mounting plate by using M20 chemical anchors. If the concrete is not more than 300 mm in thickness, an independent foundation should be constructed, meaning that it is required to carry out reviewing before the construction work. Place the robot's main body on the mount plate, and then fasten it with 8 bolts of M20.

- Bolt : M20*70 (strength grade: 12.9)
- Plain washer : T = 4mm or above, Inner diameter (ID) = 24, Hardness = HrC 35 or above
- Fastening torque: 5700 kgfcm

3.5.3. Accuracy of Installation Surface

The flatness of the four installation surfaces on the plate attachment surface of the manipulator and their height errors should satisfy the designated specifications. Shims should be used when necessary.

■ **Cautions**

① The flatness of mounting plate must be within 0.5 mm.
② The error in the heights of the four plate attachment surfaces should be within 0.5 mm.

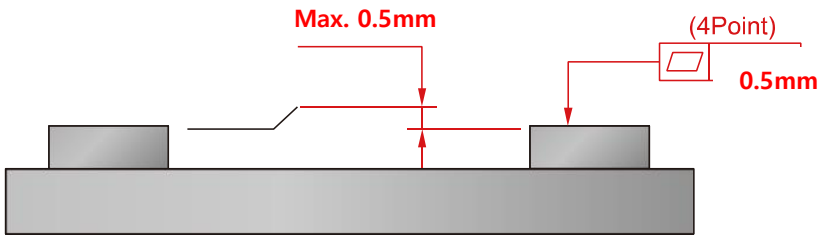


Figure 3.5 Accuracy of Installation surface

3.5.4. Dimension of Installation Surface

To attach the robot's main body, fix the bottom surface of the swivel base.
Refer to [Figure 3.6] for dimensions.

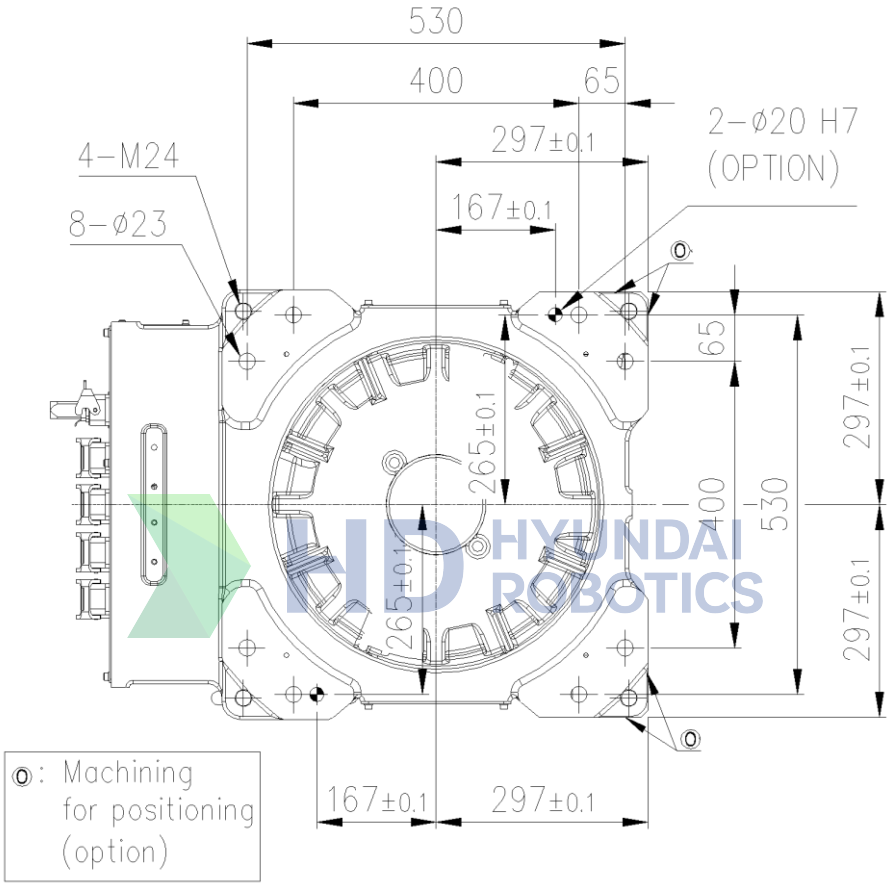


Figure 3.6 Dimension of Robot Installation

3.5.5. Robot Cable Connection

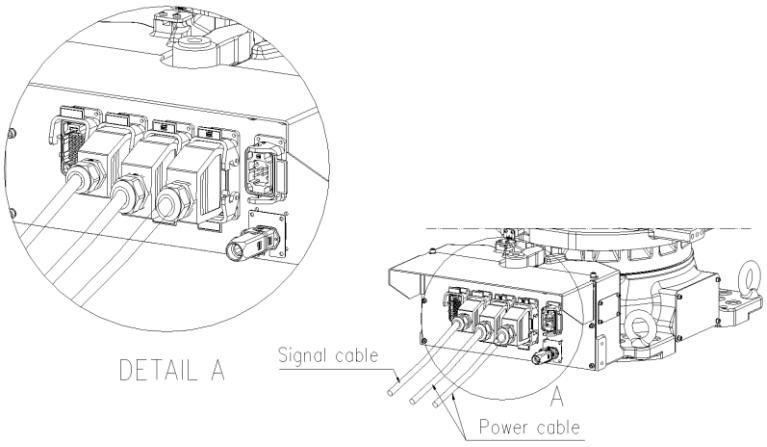


Figure 3.7 Robot Cable Connection (HS210E)

The robot is connected to the controller through a power cable and a signal cable. 0| Cable Connect these cables to the connector on the back of the robot base. Connect the ground wire or pneumatic and optional cable connection, refer to '2.7 Application Wiring and Inspection Wiring Diagram' page.

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

3.5.6. Emergency Stop time & Distance

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

- HS210E

  S-axis
  Max time : 0.85 seconds
  Max Moving Distance : 54.33 Inch / 1380 mm

  H-axis
  Max time : 0.89 seconds
  Max Moving Distance : 61.18 Inch / 155.5 mm

  V-axis
  Max time : 0.81 seconds
  Max Moving Distance : 47.40 Inch / 1204 mm

3.6. Allowable Load of Wrist Axis

3.6.1. Permitted load torque estimation

The load, which will be applied to the mechanical interface of robot's wrist axis, is restricted by allowable weight, allowable load torque and allowable moment of inertia.

- Step 1
  Calculate the position of the center of gravity at the center of rotation of the B axis (L_X, L_Y and 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 B axis and R1 axis to the center of gravity.
  $$L_B = \sqrt{L_X{}^2 + L_Z{}^2}, \quad L_{R1} = \sqrt{L_Y{}^2 + L_Z{}^2}$$
  L_B: Distance from the center of rotation of B axis to the center of gravity.
  L_{R1}: Distance from the center of rotation of R1 axis to the center of gravity

- Step 3
  Calculate the load torque from 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 R1 axis
  M: Mass of load
  g: Gravitational acceleration

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

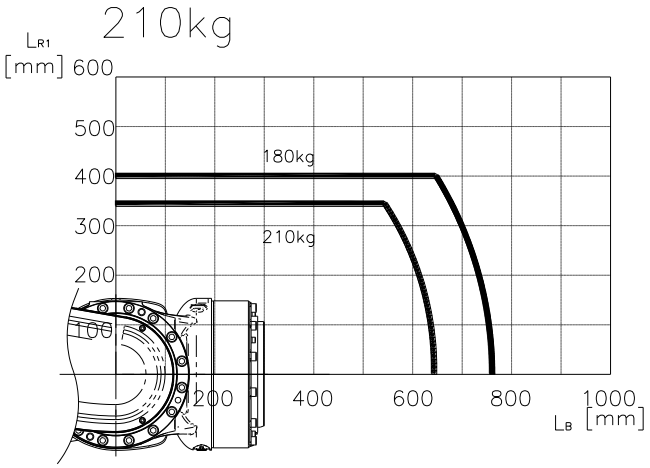


Figure 3.8 Troque diagram of the wrist axis

Allowable Load Torque

Table 3-1 Allowable Load Torque

Payload	Allowable Load Torque		
	R2 Axis Rotation	B Axis Rotation	R1 Axis Rotation
210 kg	Less than 1,334 N·m (136 kgf·m)		Less than 706 N·m (72 kgf·m)

3.6.2. Permitted inertia moment estimation

Refer to [Table 3-2] in using the robot so that the load does not exceed the allowable condition.

- Step 1
  Calculate moment of inertia of the load at the center of each wrist 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

Check if the moment of inertia is below the limit value, based on the table of allowable moments of inertia below.

Allowable Moment of Inertia

Table 3-2 Allowable Moment of Inertia

Payload	Allowable Moment of Inertia		
	R2 Axis Rotation	B Axis Rotation	R1 Axis Rotation
210 kg	200 kg·m² (20.4 kgf·m·s²)		155 kg·m² (15.8 kgf·m·s²)

3.6.3. Example of permitted torque and inertia moment calculation

(1) Case #1 Simple 2-D model

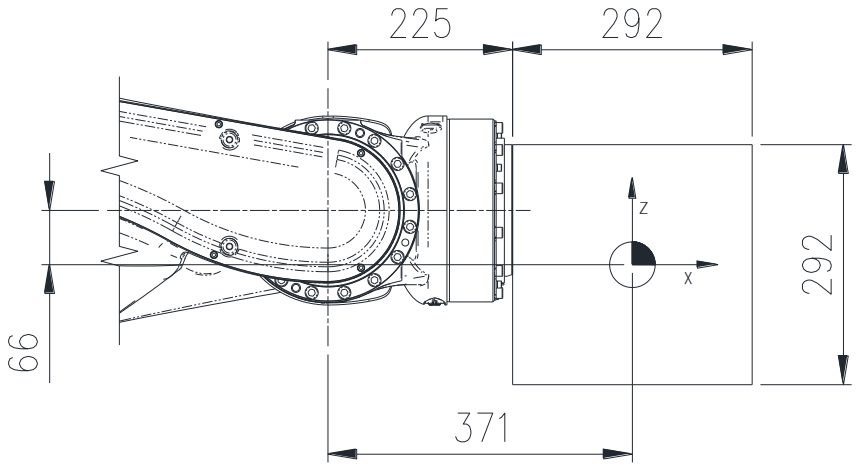


Figure 3.9 2-D load model

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

☞ Load condition: Stainless steel with width, depth, and thickness of 292 mm each (Mass 141.3kg) (Mass 141.3kg)

① Weight limit
Load weight: $141.3 \leq 210$ kg

② Limit of the allowable torque
Position of the center of gravity based on the B axis: LX = 366 mm, LY = 0 mm and LZ = -76 mm
The distance from the B and R1 axes to the center of gravity is calculated as follows.
Distance based on the B axis: $L_B = \sqrt{0.366^2 + 0.076^2} = 0.374$ m
Distance based on the R1 axis: $L_{R1} = 0.076$ m
Load torque of the B axis: $T_B = MgL_B = 52.8$ kgfm ≤ 136 kgfm
Load torque of the R1 axis: $T_{R1} = MgL_{R1} = 10.7$ kgfm ≤ 72 kgfm

③ Limit of the allowable moment of inertia
Moment of inertia of the load at the center of gravity
Jxx= 2.83 kgm^2, Jyy= 2.83 kgm^2, Jzz= 2.83 kgm^2
Moment of inertia of the B axis (Ja5)
$J_{a5} = ML_B^2 + J_{yy} = 141.3 \times 0.374^2 + 2.83 = 22.6 \leq 200$ kgm^2
Moment of inertia of the R1 axis
$J_{a6} = ML_{R1}^2 + J_{xx} = 141.3 \times 0.076^2 + 2.83 = 3.65 \leq 155$ kgm^2

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

(2) Case #2 Complicated 3-D model

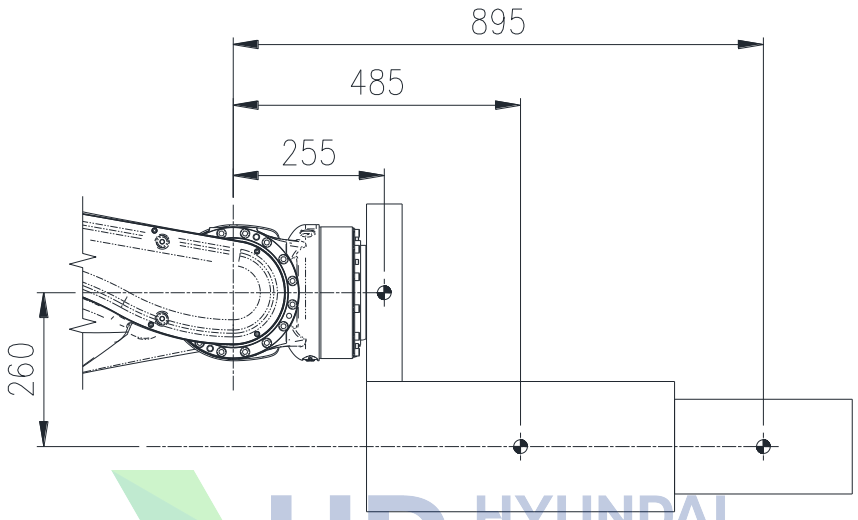


Figure 3.10 HS165 3-D load model 2-D shape (HS210E)

Aluminum block shape combination
(σ =0.00287 g/mm^3, : 201.3 kg)
m_1 (60×300×300) 15.5kg
m_2 (520×440×220) 144.5kg
m_3 (300×300×160) 41.3kg

mi - i Weight of i block load
LXi - i Weight center location in X axis direction of I block
LYi - i Weight center location in Y axis direction of I block
LZi - i Weight center location in Z axis direction of I block

⑤ Weight limit
Load weight : $201.3 \leq 210$ kg

⑥ Permitted torque limit

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

$$L_x = \frac{\sum_i m_i L_{xi}}{\sum_i m_i} = \frac{15.5 \times 250 + 144.5 \times 480 + 41.3 \times 890}{201.3} = 546.4 \text{ mm}$$

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

$$L_z = \frac{\sum_i m_i L_{zi}}{\sum_i m_i} = \frac{15.5 \times 0 + 144.5 \times 260 + 41.3 \times 260}{201.3} = 240.0 \text{ mm}$$

The weight center location for the total load from the B axis rotation center Lx = 546.4mm, Ly = 0mm, L_z = -240.0mm

Distance from B axis to center of gravity $L_B = \sqrt{0.546^2 + 0.240^2} = 0.596$ m
Distance from R1 axis to center of gravity $L_{R1} = \sqrt{0.240^2 + 0.0^2} = 0.240$ m

B axis load torque $T_B = MgL_B = 120.0 \text{ kgfm} \leq 136 \text{ kgfm}$
R1 axis load torque $T_{R1} = MgL_{R1} = 48.3 \text{ kgfm} \leq 72 \text{ kgfm}$

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

LX1, LY1, LZ1 – Weight center location of block m1 from B axis rotation center
LX2, LY2, LZ2 - Weight center location of block m2 from B axis rotation center
LX3, LY3, LZ3 - Weight center location of block m3 from B axis rotation center

Jxx1, Jyy1, Jzz1 – Inertia moment by x, y and z axis from the weight center of block m1
Jxx2, Jyy2, Jzz2 – Inertia moment by x, y and z axis from the weight center of block m2
Jxx3, Jyy3, Jzz3 – Inertia moment by x, y and z axis from the weight center of block m3

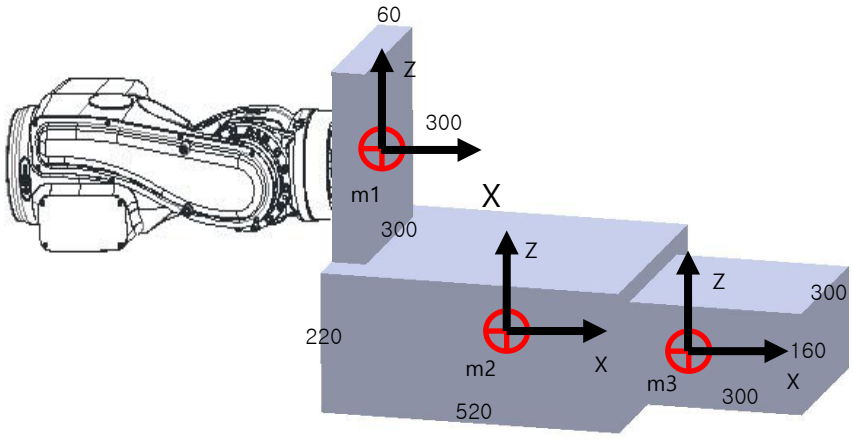


Figure 3.11 3-D load model 3-D shape

⑦ Permitted inertia moment limit

Table 3-3 Inertia moment from weight center by block

Block weight (kg)	Weight center(L_X, L_Y, L_Z)	J_{xx}	J_{yy}	J_{zz}
m_1 (15.5)	(0.25, 0, 0)	0.232 kgm^2	0.121 kgm^2	0.121 kgm^2
m_2 (144.5)	(0.48, 0, -0.26)	2.913 kgm^2	3.838 kgm^2	5.586 kgm^2
m_3 (41.3)	(0.89, 0, -0.26)	0.398 kgm^2	0.398 kgm^2	0.620 kgm^2

B axis inertia moment (J_{a5})

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

$$= [15.5 \times (0.25^2) + 0.121] + [144.5 \times (0.48^2 + 0.26^2) + 3.838] + [41.3 \times (0.89^2 + 0.26^2) + 0.398] = 83.9 \leq 200 \text{ kg}m^2$$

R1 axis inertia moment (J_{a6})

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

$$= [15.5 \times (0^2) + 0.232] + [144.5 \times (0.26^2) + 2.913] + [41.3 \times (0.26^2) + 0.398] = 16.1 \leq 155 \text{ kg}m^2$$

⑧ Conclusion

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

4 Inspection

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

4.1. Inspectoin plan

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

The inspection periods have been reviewed for SPOT Welding. In case of high precision work such as handling, it is recommended to inspect at the half intervals of that period as shown in [Table 4-1].

Table 4-1 Inspection Schedule

Daily Inspection	**Daily**	The main body, motors, reducers, gas springs, and the bearings of gas springs
Yearly Inspection	**3months**	Wiring, bolts, reducers, and the bearings of gas springs
	6months	Gas springs and timing belts
	1years	Limit switches/dogs and breaks

4.2. Inspection Items and Period

Table 4-2 Inspection Items and Period

No	Inspection Intervals				Inspection Items	Inspection method	Standards	Remark
	Daily	3M	6M	1Y				
Robot Manipulator and Axes common								
1	○				Cleaning	Examine dirt and dust with naked eyes		
2		○			Inspection wiring	Examine any cable damages Examine cable fixing bracket tightening bolts paint marking with naked eyes Examine any cable cover damages with naked eyes		
3		○			Main bolts	Examine paint marking with naked eyes		
4				○	Limit Switch/ Dog	Check the ON-OFF function of limit switch	Check if the emergency stop lamp is on when the limit switch is ON.	
5	○				Motor	Check the abnormal heating Check the abnormal sound		
6				○	Brake	Check the ON/OFF operation of brake release switch Note) Turn the switch off in a second because the ARM of working axis may be dropped when the brake release switch is on	When the brake release switch is OFF, ARM of End Effect will not be dropped.	
Axis S, H, V								
7	○				Reduction gear	Check the abnormal sound Check the shaking(vibrating)		
8	○				Gas spring load	Check the load surface damage		
9			○	○	Gas spring Presure	Check pressure	See '9. Gas spring Maintenance'	
10	○				Gas spring Bearing	Check Oily grease spilled out, Overheating of bearing part and foreign object, and excessive Eccentricity in BS JOINT	Maintain proper grease on bearing	

Axis R2, B, R1								
11		○			Reduction gear	Check the abnormal sound Check the vibrating		
12		○			End Effect tightening bolts	Examine paint marking with naked eyes		
13		○			Diversion	there is any diversion by rotating each axis to the right and reverse direction	should not feel diversion by touch	
14			○	○	Timing Belt	Check the presence of play by rotating the B / R1 axis in the forward / reverse direction	See '5.4 Replacing the timing belt'	

- If the robot is utilized in adverse condition(such as spot welding, grinding, etc.), perform the inspection more frequently to ensure proper reliability of the robot system
- Inspect all visible cabling, and replace them if damaged.
- Check the mechanical bumper devices for deformation and damage. If the bumper or Dog is bent, replace it immediately.
- Check the tightening torque of main bolts as shown in [Figure 4.1].
- Check the abnormal noise in an automatic or teaching mode in order to ensure the condition of power transmission(such as motor, reduction gear, etc).

- Inspect the gas springs regularly to keep the pressure at a proper level and inject gas when the pressure is lowered.

- Replace some parts of the gas springs after a certain period of use.

4.3. Inspection of Main External Bolts

The recommended bolt torque is shown in [Figure 4.1].
Apply the appropriate torque, where required, using the torque wrench and place the paint marking where the check-up is completed. Use 12.9T (strength grade) for bolts.

Table 4-3 Inspection part for main bolts

No.	Inspection parts	No.	Inspection parts
1	H-axis reduction gear seal bolt	9	B-axis reduction gear seal bolt
2	H-axis motor seal bolt	10	B-axis motor seal bolt
3	V-axis reduction gear seal bolt	11	R1-axis reduction gear seal bolt
4	V-axis motor seal bolt	12	R1-axis motor seal bolt
5	Upper gas plate attachment bolt	13	End effector attachment bolt
6	Arm pipe attachment plate	14	B axis idler attachment bolt
7	R2-axis reduction gear seal bolt	15	R1 axis idler attachment bolt
8	R2-axis motor seal bolt		

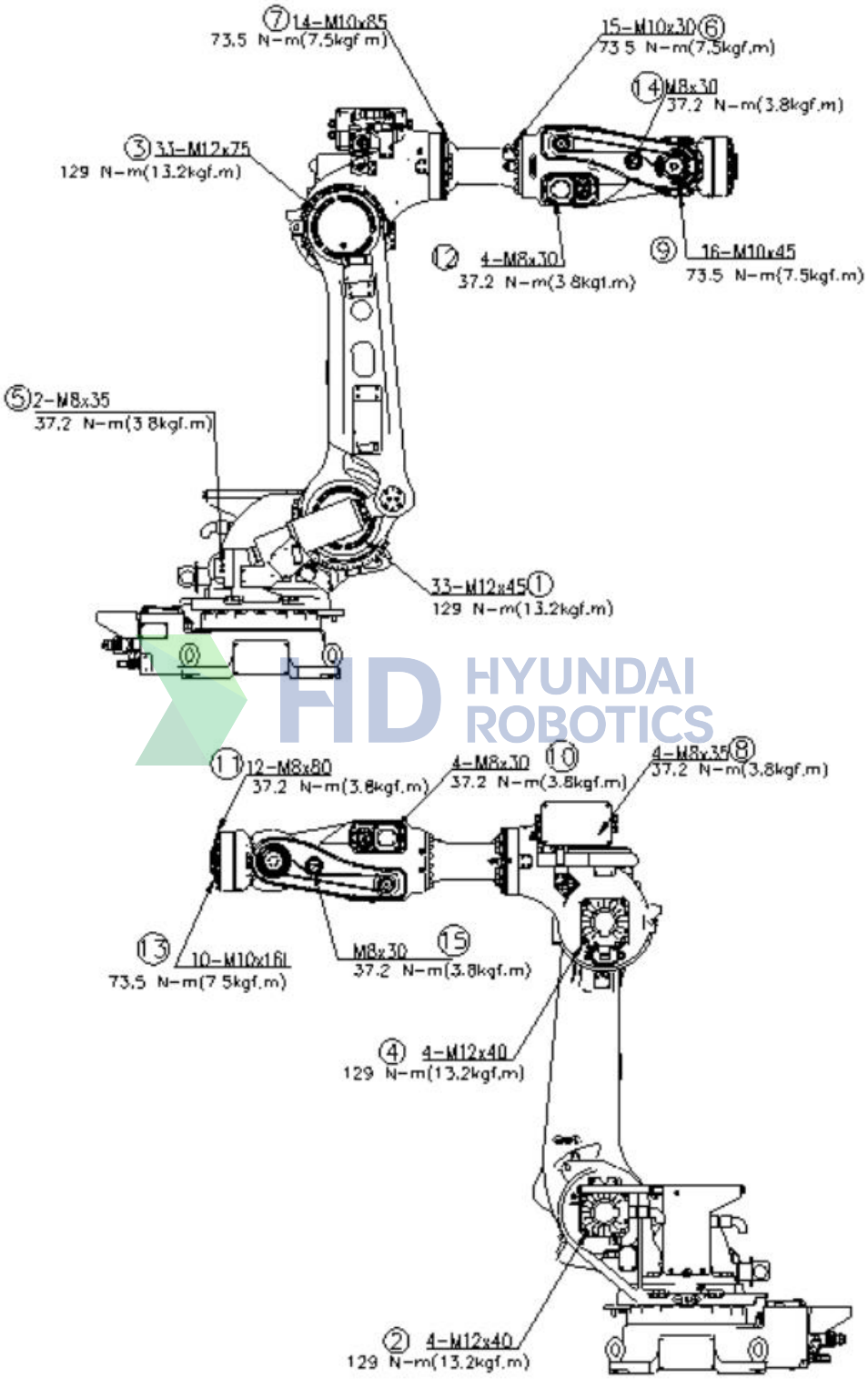


Figure 4.1 Inspection Part for Main Bolts

4.4. Timing belt check

The wrist axis drive part is driven by a timing belt. When it comes to the timing belt driving, check the belt tension after every 1,500 hr or when vibration/noise occurs. Improperly tensioned timing belts may have a significant negative impact on the performance of the robot.

■ Checking the timing belt
① Turn off the power.
② Remove the wrist cover.
③ Place the microphone of the sonic belt tensioner on the belt opposite to the idler and apply impact to the belt.
④ Check the tension frequency value.
⑤ If the tension frequency value is outside the tension frequency range in the table below, loosen the idler bolt a little bit.
⑥ Rotate the idler to adjust the timing belt tension and fasten the idler bolt (340 kgfcm).
⑦ Check the tension frequency value again and repeat the above steps ⑤ ~ ⑥ to ensure that the tension comes within the tension frequency range in the table below.
⑧ Assemble the wrist cover.
⑨ Turn on the power.

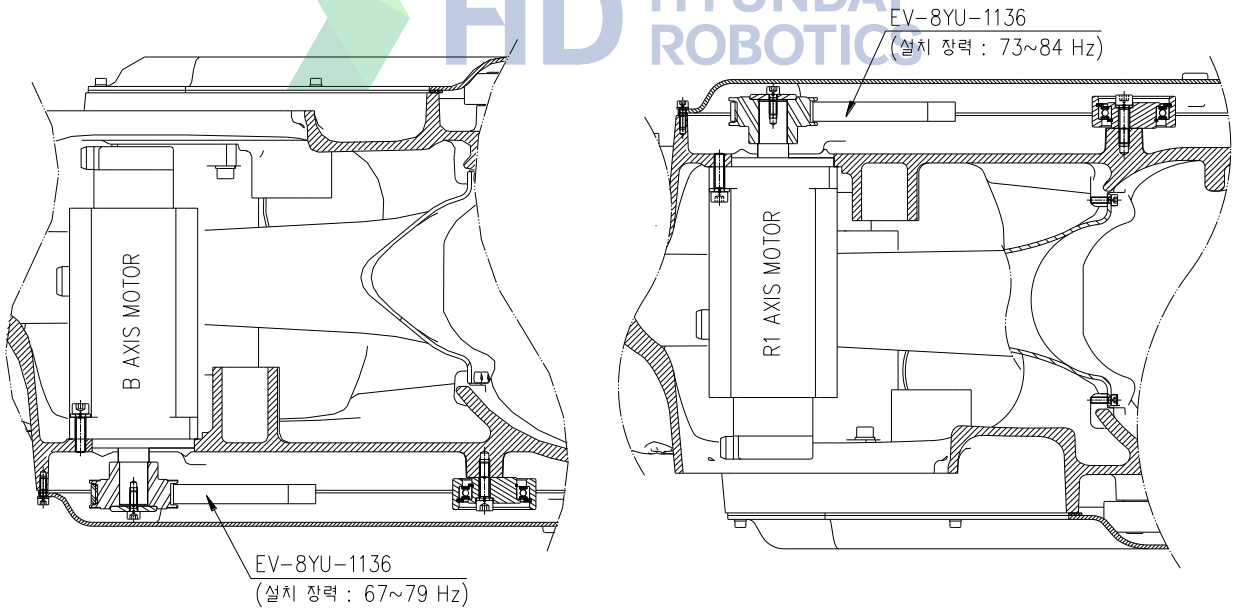


Figure 4.2 Timing belt tension check area

Table 4-4 Timing belt tension

	B axis	R1 axis
Tension range	67 ~ 79 Hz	73 ~ 84 Hz

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5 Maintenance

5.1. Grease Replenishment/Replacement

Attention

If greasing is performed incorrectly, the internal pressure of the grease bath may suddenly increase, possibly causing damage to the seal, which would in turn lead to grease leakage and abnormal operation. When performing greasing, therefore, observe the following cautions.

(1) Be sure to wear protective glasses before injecting and inspecting grease.

(2) Be sure to remove the grease outlet plug before injecting grease.

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

(4) If possible, do not use a compressed air pump driven by the air supplied from the factory, and limit the grease injection pressure to 2.5 bar (2.5 kgf / cm2) or below.

(5) Use only the designated grease. Otherwise, damage to the reducer and other problems could occur.

(6) After injecting the grease, check whether the grease outlet is leaking and whether there is no pressure at the inlet before fastening the plug.

(7) To prevent accidents, clean the grease leaked onto the robot's main body or floor.

(8) When using the robot at an ambient temperature of 35 ° C or higher, reduce the grease replenishment and replacement cycles by half.

■ **Procedures for replacing the grease and for removing the over-injected grease and residual pressure.**

(1) Attach a grease tray or hose to the grease outlet to prevent the surroundings from being contaminated by the discharged grease.

(2) Will operate under 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 %	20 minutes at least
Axis 4 ~ Axis 6	60° /120° /60° or above	100 %	20 minutes at least
Arm gearbox	60° /120° /60° or above	100 %	20 minutes at least

(3) Wipe the outlet with a cloth and assemble the plug back into its origianl place.

■ **Periodic Replenishment / Replacement**

Periodic Replenishment / Replacement

- ✓ **S axis reducer and the arm frame gearbox: Every 24,000 hours**
- ✓ **Other reducers : Every 12,000 hours**
- ✓ **Bearings of the gas spring : Every 6 months (Every 3 months under severe conditions)**

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

The noise may be caused by following reasons

1. Operation after greasing or replacing the reducer
2. Operation after long-term storage
3. Operation at a low speed
4. Operation at a low temperature

5.1.1. S-Axid Reduction Gear (HS210E)

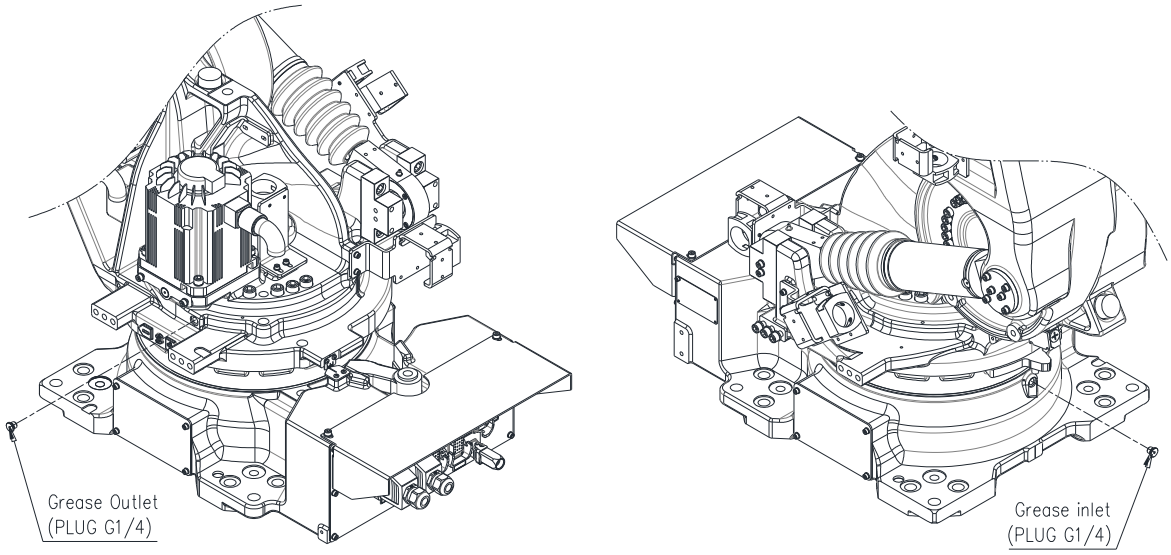


Figure 5.1 S Axis reducer grese inlet/outlet

Attention

If grease is injected without removing the outlet plug, the internal pressure may increase, leading to grease leakage, and grease may enter and damage the motor. Be sure to remove the plug.

■ Grease Replenishment

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

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

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

(4) Inject the grease through the inlet by using the grease gun.

- ✓ **Grease type : VIGO GREASE RE0**
- ✓ **Amount of grease : 3,367cc (3.0kg, for reference)**

(5) Inject the new grease until it comes out of the outlet.
The new grease can be identified by color.

(6) Remove the residual grease while moving the S axis for a few minutes, and then inject the new grease until it comes out of the outlet.

(7) Release the over-injected grease and residual pressure (refer to the following removal procedures)

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

■ Injecting the grease after replacing the reducer

(1) Prepare the nipple A-PT 1/4.

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

(3) Remove the grease outlet plug G1/4 and air vent set, and then fasten the plug G1/4 to the air vent set.

(4) Inject the grease through the inlet by using the grease gun.

✓ Type of grease: VIGO GREASE RE0
✓ Amount of grease: 4,200cc (3.8kg)

(5) Inject the new grease until it comes out of the outlet.

(6) Release the over-injected grease and residual pressure (refer to the following removal procedures)

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

■ Procedures for replacing the grease and injecting new grease and then removing the over-injected grease and residual pressure

(1) Attach a grease tray or hose to the grease outlet to prevent the surroundings from being contaminated by the discharged grease.

(2) Will operate under the following conditions within the range that does not cause interference with the surroundings.

① Operation angle: 90° or above
② Operation speed: 100%
③ Operation time: 20 minutes or above

(3) Wipe the outlet with a cloth and assemble the plug back into its original position.

5.1.2. H-Axis Reduction Gear (HS210E)

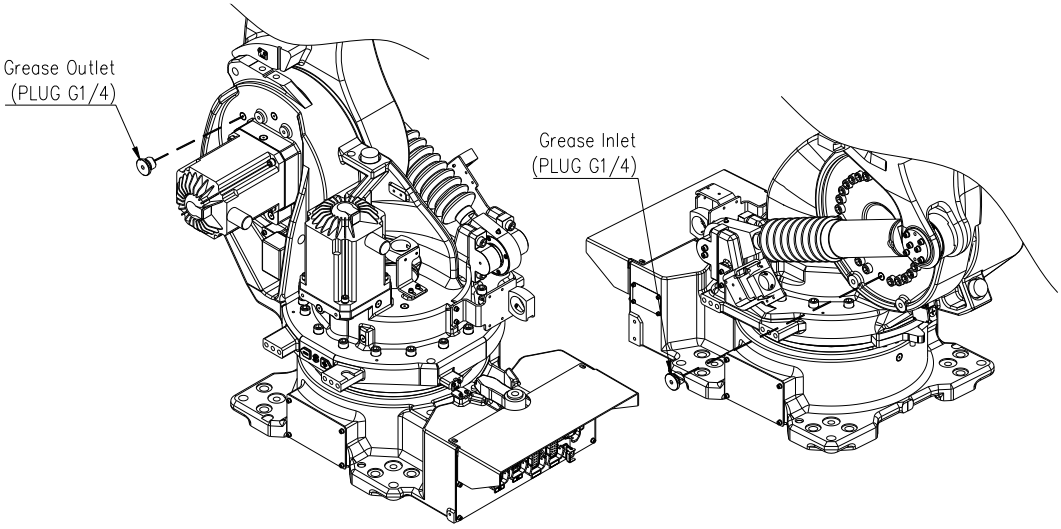


Figure 5.2 H axis reducer grease inlet/outlet

Attention

If grease is injected without removing the outlet plug, the internal pressure may increase, leading to grease leakage, and grease may enter and damage the motor. Be sure to remove the plug.

■ Grease Replenishment

(1) Prepare the grease nipple A-PT1/4 and make the H axis arm in a vertical position. (H:90° -Floor Type, H:0° -Shelf Type).

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

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

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

- ✓ **Type of grease: VIGO GREASE RE0**
- ✓ **Amount of grease: 2,175cc (2.0kg, for reference)**

(5) Inject the new grease until it comes out of the outlet.
The new grease can be identified by color.

(6) Remove the residual grease while moving the H axis for a few minutes, and then inject the new grease until it comes out of the outlet.

(7) Release the over-injected grease and residual pressure (refer to the following removal procedures).

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

■ Injecting the grease after replacing the reducer

(1) Prepare the grease nipple A-PT1/4 and make the H axis arm in a vertical position (H:90° -Floor Type, H:0° -Shelf Type).

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

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

(4) Inject the grease through the inlet by using the grease gun.

✓ Type of grease: VIGO GREASE RE0
✓ Amount of grease: 2,900cc (2.6kg)

(5) Inject the new grease until it comes out of the outlet.

(6) Release the over-injected grease and residual pressure (refer to the following removal procedures).

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

■ Procedures for replacing the grease and injecting new grease and then removing the over-injected grease and residual pressure

(1) Attach a grease tray or hose to the grease outlet to prevent the surroundings from being contaminated by the discharged grease.

(2) Will operate under the following conditions within the range that will not cause interference with the surroundings.

① Operation angle: 90° or above
② Operation speed: 100%
③ Operation time: 20 minutes or above

(3) Wipe the outlet with a cloth and assemble the plug as it was.

5.1.3. V-Axis Reduction Gear (HS210E)

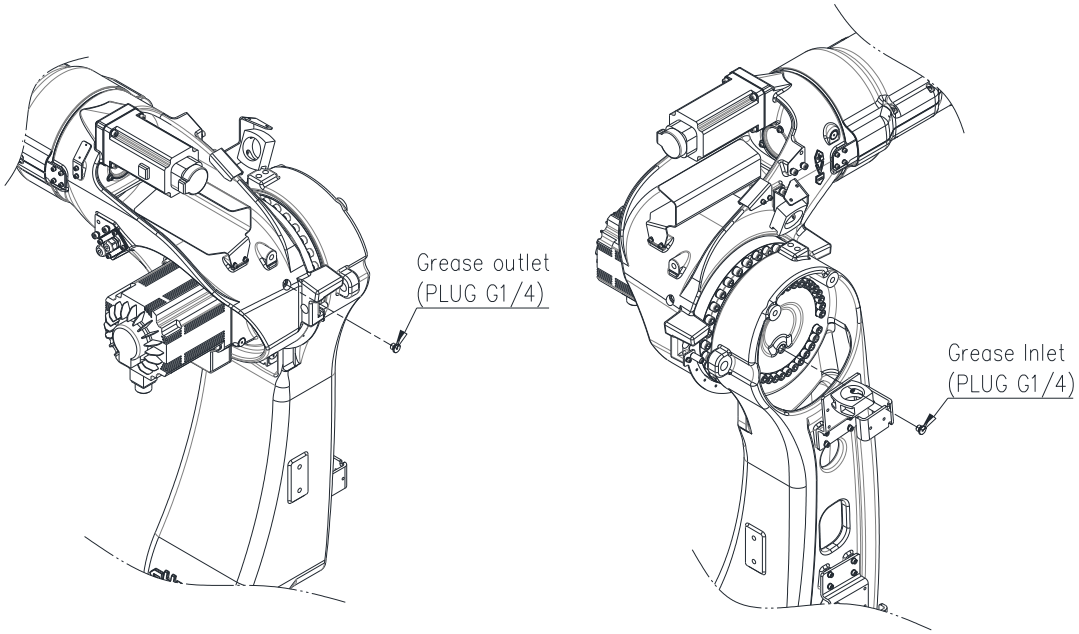


Figure 5.3 V-axis reducer grease injection/discharge port

Attention

If grease is added without removing the outlet plug, it cause damage to the seal of reduction gear and grease will go inside the motor and may damage it. It is absolutely necessary to remove the plug.

■ Grease Replenishment

(1) Make the V-Axis Arm horizontal for ground.(V:0° -Floor Type, V:-90° -Shelf Type)

(2) Remove the grease inlet plug G1/4 and install grease nipple A-PT1/4

(3) Remove the grease outlet plug G1/4

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

- ✓ **Grease type : VIGO GREASE RE0**
- ✓ **Amount of grease : 2,303cc (2.1kg, for reference)**

(5) Inject the new grease until it comes out of the outlet.
The new grease can be identified by color.

(6) Remove the residual grease while moving the V axis for a few minutes, and then inject the new grease until it comes out of the outlet.

(7) Release the over-injected grease and residual pressure (refer to the following removal

procedures)

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

■ Injecting the grease after replacing the reducer

(1) Prepare the grease nipple A-PT1/4 and make the V axis arm in a vertical position (H:90° -Floor Type, H:0° -Shelf Type).

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

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

(4) Inject the grease through the inlet by using the grease gun.

- ✓ **Grease type : VIGO GREASE RE0**
- ✓ **Amount of grease : 3,070cc (2.8kg)**

(5) Inject the new grease until it comes out of the outlet.

(6) Release the over-injected grease and residual pressure (refer to the following removal procedures).

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

■ Procedures for replacing the grease and injecting new grease and then removing the over-injected grease and residual pressure

(1) Attach a grease tray or hose to the grease outlet to prevent the surroundings from being contaminated by the discharged grease.

(2) Will operate under the following conditions within the range that will not cause interference with the surroundings.
① Operation angle : 70° or above
② Operation speed : 100%
③ Operation time : 20minutes or above

(3) Wipe the outlet with a cloth and assemble the plug as it was.

5.1.4. R2-Axis Reduction Gear

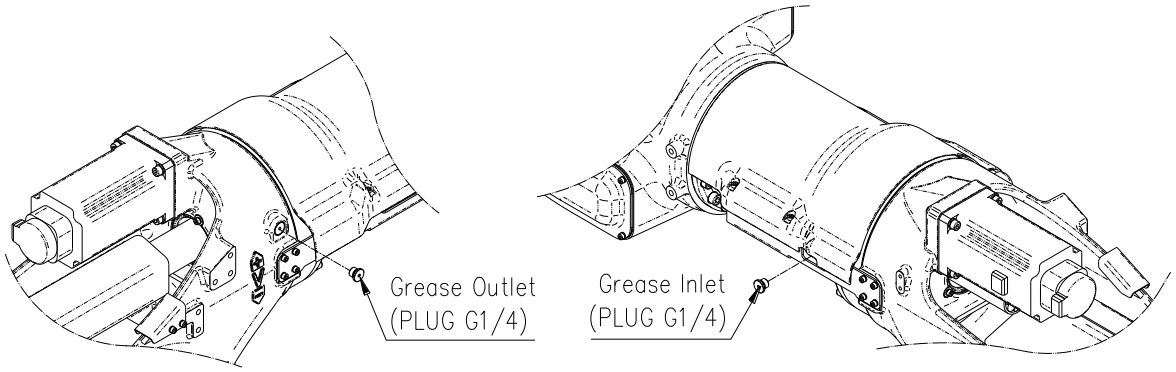


Figure 5.4 R2-axis reducer grease injection/discharge port

Attention

Do not inject excessive grease. The excessive grease would cause an abnormal operation.

■ Grease replenishment

(1) Prepare the grease nipple A-PT1/4. (V: 0° -Floor type,R2: 0° -Floor type)

(2) Remove the bottom Arm Cover and Grease inlet plug G1/4, Install grease nipple A-PT1/4

(3) Remove the Grease Outlet plug G1/4.

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

- ✓ **Grease type : VIGO GREASE RE0**
- ✓ **Amount of grease : 1,236cc (1.1kg, for reference)**

(5) Inject the new grease until it comes out of the outlet.
The new grease can be identified by color.

(6) Remove the residual grease while moving the R2 axis for a few minutes, and then inject the new grease until it comes out of the outlet.

(7) Release the over-injected grease and residual pressure (refer to the following removal procedures)

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

■ Injecting the grease after replacing the reducer

(1) Prepare the grease nipple A-PT1/4. (V: 0° -Floor type,R2: 0° -Floor type)

(2) Remove the bottom Arm Cover and Grease inlet plug G1/4, Install grease nipple A-PT1/4

(3) Remove the Grease Outlet plug G1/4.

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

- ✓ **Grease type : VIGO GREASE RE0**
- ✓ **Amount of grease : 1,648cc (1.5kg)**

(5) Inject the new grease until it comes out of the outlet.

(6) Release the over-injected grease and residual pressure (refer to the following removal procedures).

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

■ Procedures for replacing the grease and injecting new grease and then removing the over-injected grease and residual pressure

(1) Remove the Arm cover and Attach a grease tray or hose to the grease outlet to prevent the surroundings from being contaminated by the discharged grease.

(2) Will operate under the following conditions within the range that will not cause interference with the surroundings.

① Operation angle : 60° or above
② Operation speed : 100%
③ Operation time : 20minutes or above

(3) Wipe the outlet with a cloth and assemble the plug as it was.

5.1.5. B-Axis Reduction Gear

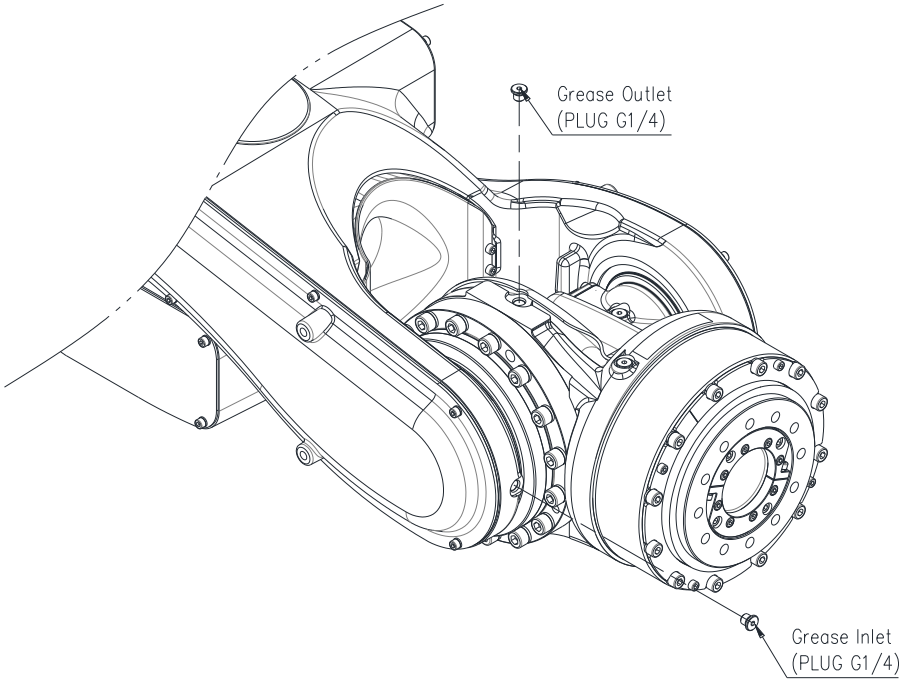


Figure 5.5 B-axis reducer grease injection/discharge port

Attention

Do not inject excessive grease. The excessive grease would cause an abnormal operation.

■ Grease replenishment

(1) Prepare the grease nipple A-PT1/4. (R: 0° -Floor type, B: 0° -Floor type)
(2) Remove the Grease inlet plug G1/8, Install grease nipple A-PT1/8
(3) Remove the Grease Outlet plug G1/8

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

- ✓ **Grease type : VIGO GREASE RE0**
- ✓ **Amount of grease : 920cc (828g, for reference)**

(5) Inject the new grease until it comes out of the outlet.
The new grease can be identified by color.

(6) Remove the residual grease while moving the B axis for a few minutes, and then inject the new grease until it comes out of the outlet.
(7) Release the over-injected grease and residual pressure (refer to the following removal

procedures)

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

■ Injecting the grease after replacing the reducer

(1) Prepare the grease nipple A-PT1/8. (R: 0° -Floor type, B: 0° -Floor type)

(2) Remove the Grease inlet plug G1/8, Install grease nipple A-PT1/8

(3) Remove the Grease Outlet plug.

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

- ✓ **Grease type : VIGO GREASE RE0**
- ✓ **Amount of grease : 860cc (774g)**

(5) Inject the new grease until it comes out of the outlet.

(6) Release the over-injected grease and residual pressure (refer to the following removal procedures)

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

■ Procedures for replacing the grease and injecting new grease and then removing the over-injected grease and residual pressure

(1) Attach a grease tray or hose to the grease outlet to prevent the surroundings from being contaminated by the discharged grease.

(2) Will operate under the following conditions within the range that will not cause interference with the surroundings.
① Operation angle : B-axis 120° or above
② Operation speed : 100%
③ Operation time : 20minutes or above

(3) Wipe the outlet with a cloth and assemble the plug as it was.

5.1.6. R1-Axis Reduction Gear

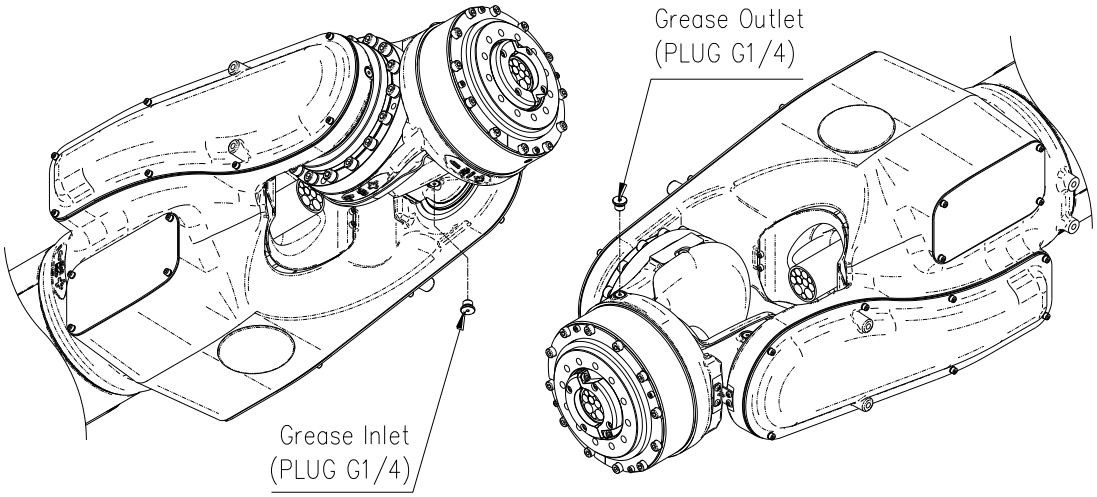


Figure 5.6 R1-axis reducer grease injection/discharge port

Attention

Do not inject excessive grease. The excessive grease would cause an abnormal operation.

■ Grease replenishment

(1) Prepare the grease nipple GPA6A. (B: 0° -Floor type, B: -90° -shelf type)
(2) Remove the Grease inlet plug SWR M6, Install grease nipple GPA6A
(3) Remove the Grease Outlet plug G1/8

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

- ✓ **Grease type : VIGO GREASE RE0**
- ✓ **Amount of Grease : 1,092cc (1.0kg, for reference)**

(5) Inject the new grease until it comes out of the outlet.
The new grease can be identified by color.

(6) Remove the residual grease while moving the R1 axis for a few minutes, and then inject the new grease until it comes out of the outlet.

(7) Release the over-injected grease and residual pressure (refer to the following removal procedures)

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

■ Injecting the grease after replacing the reducer

(1) Prepare the grease nipple A-PT1/4. (R2: 0° -Floor type, B: 0° -Floor type, R1: 0° -Floor type)

(2) Remove the Grease inlet plug SWR M5, Install grease nipple A-PT1/4
(3) Remove the Grease Outlet plug.

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

- ✓ **Grease type : VIGO GREASE RE0**
- ✓ **Amount of grease :1,455 cc (1.3 kg, for reference)**

(5) Inject the new grease until it comes out of the outlet.

(6) Release the over-injected grease and residual pressure (refer to the following removal procedures)
(7) Remove the grease nipple of the inlet and assemble the inlet plug.

■ Procedures for replacing the grease and injecting new grease and then removing the over-injected grease and residual pressure

(1) Attach a grease tray or hose to the grease outlet to prevent the surroundings from being contaminated by the discharged grease.

(2) Will operate under the following conditions within the range that will not cause interference with the surroundings.
   A. Operation angle : 60° or above
   B. Operation speed : 100%
   C. Operation time : 20minutes or above

(3) Wipe the outlet with a cloth and assemble the plug as it was.

5.1.7. Gas Spring Bearing

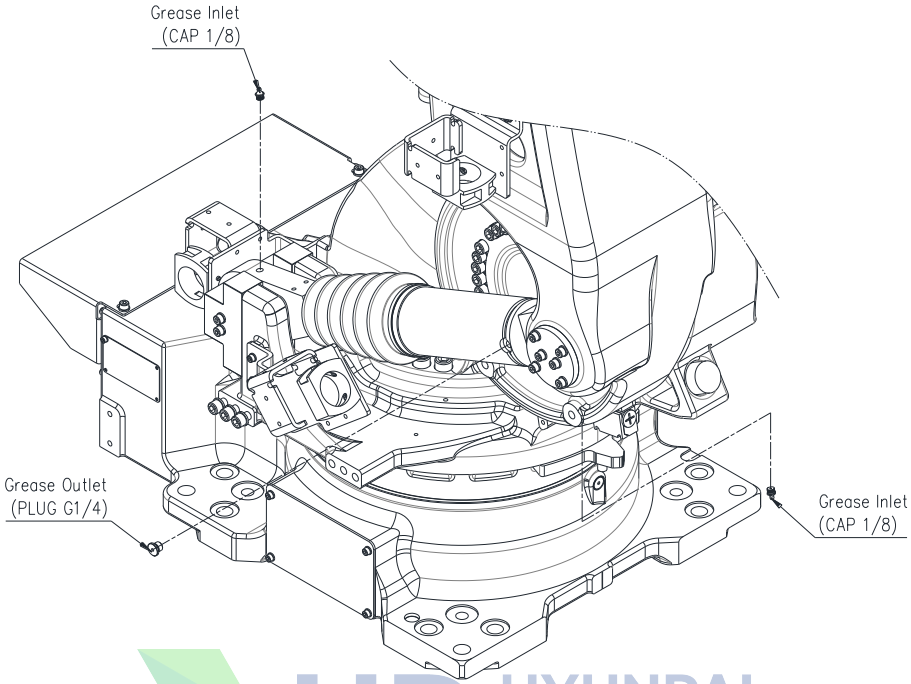


Figure 5.7 Gas Spring Grease Inlet/Outlet

■ Grease injection method

(1) Open a nipple cap 1/8, and inject grease using a grease gun through the grease nipple A-PT1/8.

- ✓ **Grease type : GADUS S2 V46 2**
- ✓ **Initial amount of grease injection: 15cc (13.5g)**
- ✓ **Amount of grease refueling: 7cc (6.3g)**

(2) Clean up discharged grease caused by excessive fueling with a cloth.
(3) Clean the inlet, and assemble the nipple cap as it was.

5.2. Battery Replacement

5.2.1. Precautions for Battery Storage

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

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

Attention

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

(1) Detach the battery cover

(2) Take out the old batteries from the battery cover

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

- ✓ **Battery Spec : ER6C(AA) 3.6V**
- ✓ **Manufacturer : Maxell**

(4) Reinstall the battery cover.

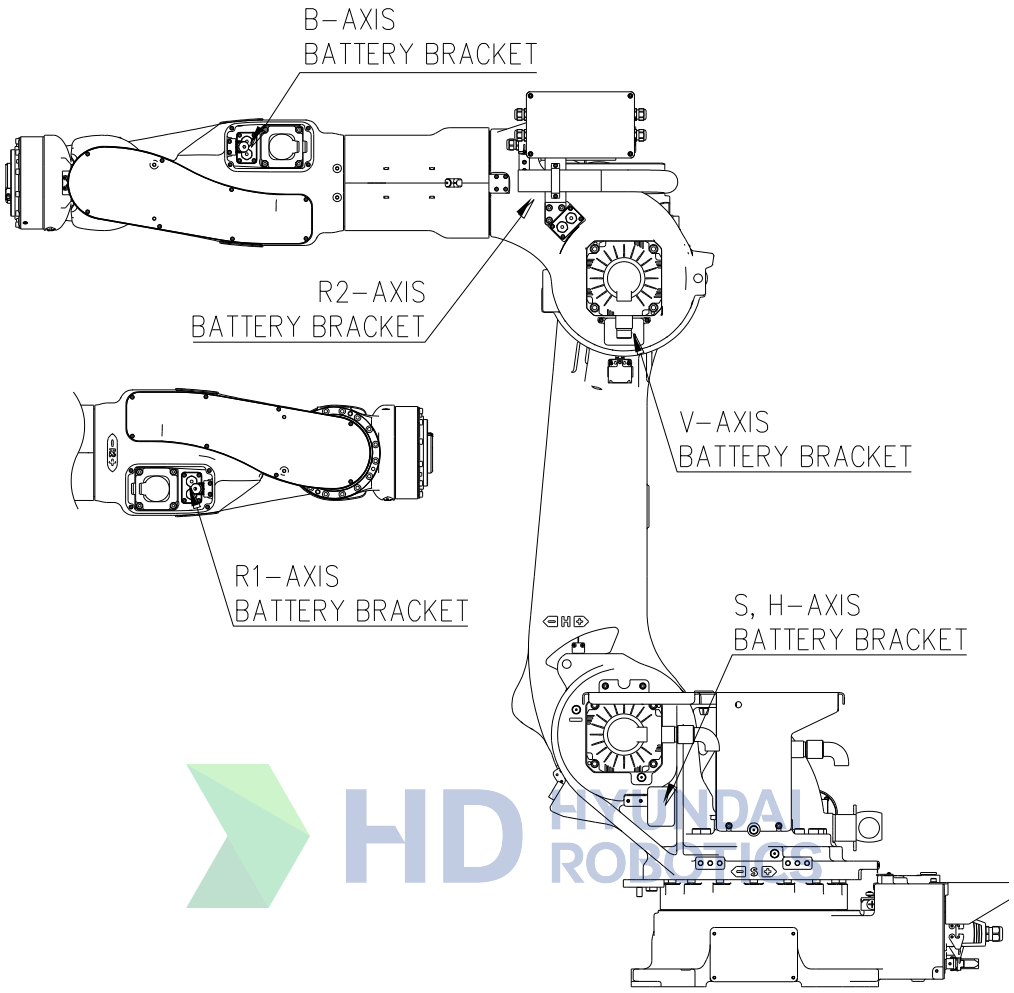


Figure 5.8 Location of Battery Replacement

Attention

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

5.3. Internal Wiring

Replacement cycle of internal wiring depends on follows.

- Continuous operation
- Operating speed
- Atmosphere/environment

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

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

Attention

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

5.4. Replacing the timing belt

The replacement cycle of the timing belt is affected by the following items.

- Continuous operation
- Operation speed
- Surrounding environment

Check periodically every 1,500 hours and check the timing belts and pulleys for any damage. If the damage is found, replacement should be performed.

(1) Since the tool may fall due to gravity, prevent the possibility of the axis from falling by using a crane or releasing the brake.
(2) Turn off the controller power. Take measures not to allow other users to turn on the power.
(3) Remove the wrist cover.
(4) Loosen the idler fastening bolts.
(5) Remove the timing belt and hook the new timing belt from the secondary pulley side to the motor side pulley.
(6) Adjust the belt tension frequency by using the idler so that it comes within the range.
(7) Fasten the idler fastening bolt.
(8) Repeat the steps (6) ~ (7) above until the tension meets the reference value in Table 4-4 Timing belt tension.
(9) Assemble the wrist cover.
(10) If the origin of the axis is out of position after the power is turned on, set the origin by referring to “6.5 Encoder zero setting”.

Caution

- ✓ Timing belts are vulnerable to oil. Please pack them individually before storing them.
- ✓ Store the timing belts away from direct sunlight.
- ✓ Keep the ambient temperature not too high or too low when storing them (should meet the reference conditions of using the robot).
- ✓ Before replacing the timing belt, check the teeth of the timing belt and pulley for any damage such as scratch.
- ✓ Do not fold the timing belt excessively.

6 Troubleshooting

6.1. Troubleshooting Procedure

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

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

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

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

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

6.2. Trouble Spymptoms and Possible Causes

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

Table 6-1 Trouble phenomenon and cause

Part with abnormality / Phenomena of troubles	Reducer	Brake	Motor	Encoder	Backlash	Grease	Gas spring	Timing belt
Overload [Note 1]	○	○	○				○	
Displacement	○		○	○				
Abnormal sound occurrence	○	○	○			○ [주5]		
Noise in operation [Note 2]			○		○			○
Staggering at stop [Note 3]			○	○				○
Irregular twitching [Note 4]			○	○				
Abnormal deviation			○	○				
Free fall of an axis	○	○						○
Overheating	○	○	○	○		○	○	
Incorrect action and out of control movement			○	○				

[Note 1] Overload ---------- Phenomenon occurring when a load exceeds the rated motor load.
In specific, thermal relay of circuit protector is tripped.
[Note 2] Noise in operation -------- Phenomenon which occurs vibration on operation.
[Note 3] Staggering at stop -------- Phenomenon which gives oscillating motion when the robot stops.
[Note 4] Irregular twitching -------- Phenomenon which gives sporadic twitching when the robot is not in
motion.
[Note 5] If there is noise from the greased part of reducer at reduced-speed operation, check the state closely for 1-2 days during operation. Generally, the noise will go away.
(The noise will go away if you run the axis at a high speed for 5-10 minutes).

The noise may be caused by following reasons.

1. Operation after greasing or replacing the reducer
2. Operation after long-term storage
3. Operation at a low speed
4. Operation at a low temperature

6.3. diagnostics and Resolutions for Major Parts Failure

6.3.1. Reducer

Vibration and abnormal sound will be occurred when a reducer is damaged. In this case, it causes overload and abnormal deviation disturbing normal operation. Sometimes overheating may result. The robot may also become completely immovable, or a position offset error may occur

[Main Axes (S, H, V)]
When turning [ON][OFF] the brake release switch of axis H and axis V, be sure to take necessary precautions to prevent the ARM from dropping, and then switch the brake release [ON][OFF]

- Diagnostics

  ① Investigate whether abnormal heat generation occurs in the parts that have a vibration or abnormal noise, as well as the reducer part, during operation.
  ② In order to check for any clearance or wear on the reducer, hold the first arm and rotate the robot while setting the S axis bake release switch to the [ON] state and check if any abnormality is felt in your hand.
  ③ Check if the robot is in contact with peripheral devices before any abnormality occurs (The reducer can be damaged by an impact from contact.)

- Resolution

  Replace the reducer. A chain block is needed to lift and hang the robot ARM. Contact our service office for any difficulties

[Wrist Axes (R2, B, R1)]
When turning [ON][OFF] the brake release switch, be sure to take necessary precautions to prevent the ARM from dropping, and then switch the brake release [ON][OFF]

- Diagnostics

  ① Check out any vibration, abnormal sound, or overheating of the reducer when the robot is in operation
  ② Check out any play in the reducer by shaking the End Effector (such as spot gun and hand devices, etc.) back and forth
  ③ Turn motors off, with the brake release switch [ON], and checks that the axis can be rotated by hand. If not, the reducer is in bad condition
  ④ Check if peripheral equipment has been contacted with the robot before the abnormality. (Damage may occur to the reducer due to the contacting impact)

- Resolution

  ① Replace the reducer
  ② Replace the entire wrist section
  (The replacement of entire wrist should be a quick and reliable resolution as it takes time and necessary equipment for reducer replacement)

6.3.2. Brakes

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

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

- Diagnostics

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

- Resolution

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

6.3.3. Motor

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

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

- Diagnostics

  Check for overheating and abnormal sound

- Resolution

  Replace the motor

6.3.4. Encoder

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

- Diagnostics

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

- Resolution

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

6.3.5. Gas springs

If the pressure of the gas spring drops excessively, overheating and overheating could occur to the motor. In addition, any damage to the surface of the piston rod of the gas spring can cause a drop in pressure. Please manage to prevent such damage from occurring.

It is required to manage to prevent the upper and lower bearings of the gas spring from being damaged due to periodic injection.

Before checking the gas spring, be sure to check whether the controller and external powers are in the 『OFF』 state. Also, take measures to prevent the controller and external powers from being turned 『ON』 accidentally by other people. Always wear protective glasses when checking the gas pressure.

- Diagnostics

  ① Check whether the cover protecting the piston rod of the gas spring is damaged.
  ② Check whether the surface of the gas spring piston rod is damaged.
  ③ Check if the pressure of the gas spring is appropriate.
  Check the pressure in compliance with “10.1. Checking the gas spring pressure”.
  ④ Check if the BS joint assembled on the upper/lower part of the gas spring assembly unit is operating with excessive eccentricity and whether there is overheating or foreign substances in the bearing part.

- Resolution

  ① When the motor is overloaded due to the gas pressure drop, or the pressure decreases below the proper level, replenish nitrogen gas or replace the gas spring assembly unit.
  ② Replace the bearing inside the BS joint if it is abnormal.
  ③ If you have any difficulty in handling, please contact our service department.
  ④ Carry out replenishing in compliance with “9.2. Replenishing the gas for gas spring”.
  ⑤ Comply with “9.4. Replacing the assembly unit of gas spring” for the pressure reference and replacement.

6.3.6. Timing Belt

If the tension of the timing belt drops, it may cause vibration and misalignment.
Please manage the timing belt by performing inspection periodically.

Before inspecting the timing belt, make sure that the controller and external powers are in the 『OFF』 state. Also, take measures to prevent the controller and external powers from being turned "ON" accidentally by other people.

- Diagnostics

  ① Shake the tool to check for clearance.
  ② Open the wrist cover and check the belt for breakage or damage.

- Resolution

  ① If there is clearance due to the belt tension drop, adjust the tension to keep it at a proper level.
  ② If the belt is found to be damaged, replace the belt immediately. Carry out a replacement in compliance with "5.4 Replacing the timing belt."
  ③ Please be advised that dust may be generated initially after the timing belt is replaced.

6.4. Motor Replacement

Warning

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

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

Table 6-2 Motor Weight by Axis

Axis	S	H	V	R2	B	R1
Weight(kg)	23.7	23.7	23.7	7.2	7.2	7.2

Warning

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

6.4.1. Necessary Tools and Parts

Table 6-3 Necessary Tools

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

Table 6-4 Necessary parts

Part name	Axis name	Use	Part number (type)
Drop-prevention bolts (option)	H axis and V axis	○	M20×250 (Standard)
	Wrist axis (R2, B, R1)	-	-

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

6.4.1. How to Replace Motor

Attention

Since the robot has a built-in brake inside the motor for keeping the arm posture, the arm will drop when the motor is disconnected. Therefore, in order to prevent the fall, the user must take safety measures such as hanging the arm with a crane, etc. and fix the first and second arms by inserting the fixing bolts.

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

(2) The axis for which a motor is to be replaced should be put into the basic posture.

(3) Refer to [Figure 6.1 ~ 6.4] in the case of the main axes (S, H an V).
In the case of the H and V axes, insert a fixing bolt to prevent the arm from dropping.
In the case of the wrist axes (R2, B and R1), set the origin by using the scale of each axis.

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

(5) Disconnect the connector from the motor

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

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

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

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

(10) Connect the connector to the motor

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

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

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

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

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

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

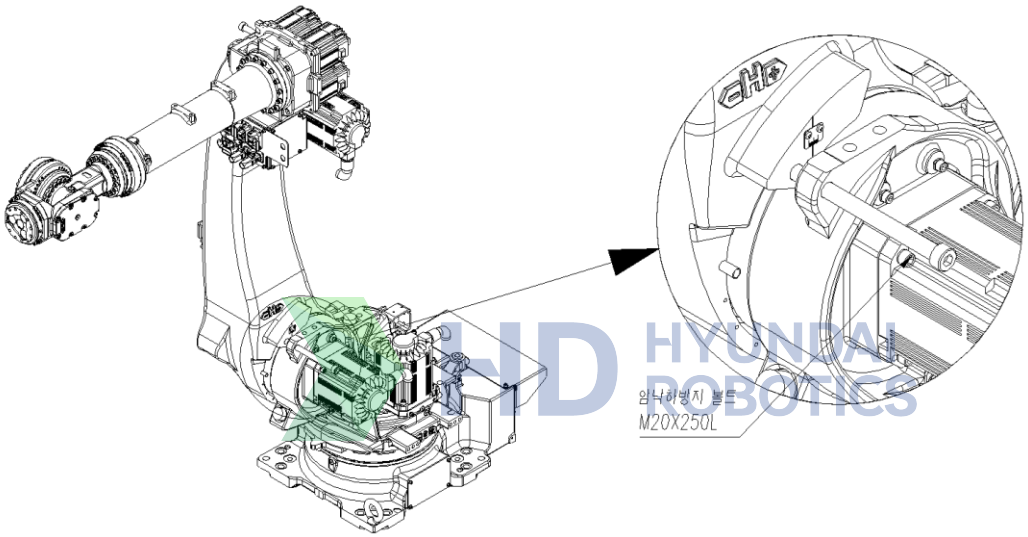


Figure 6.1 1 Arm (H axis) fixing bolt insertion position

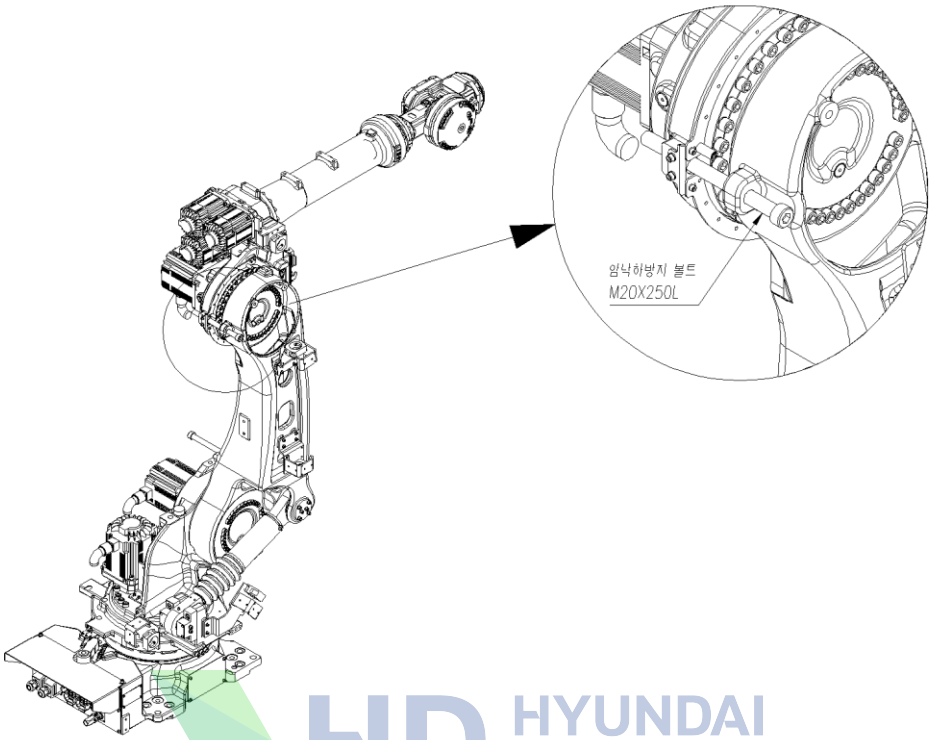


Figure 6.2 2 Arm (V axis) fixing bolt insertion position

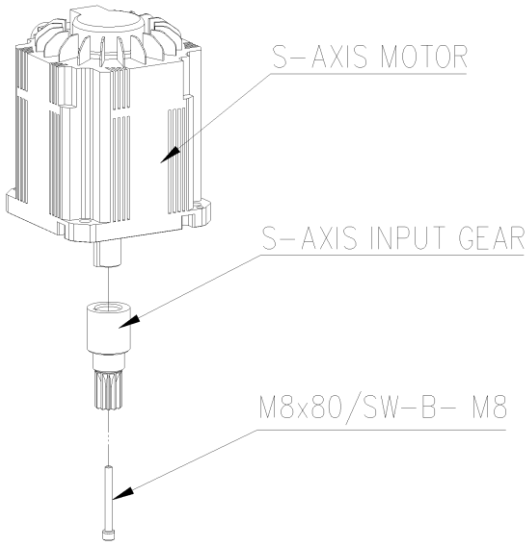


Figure 6.3 Motor assemblies of the H and V axes

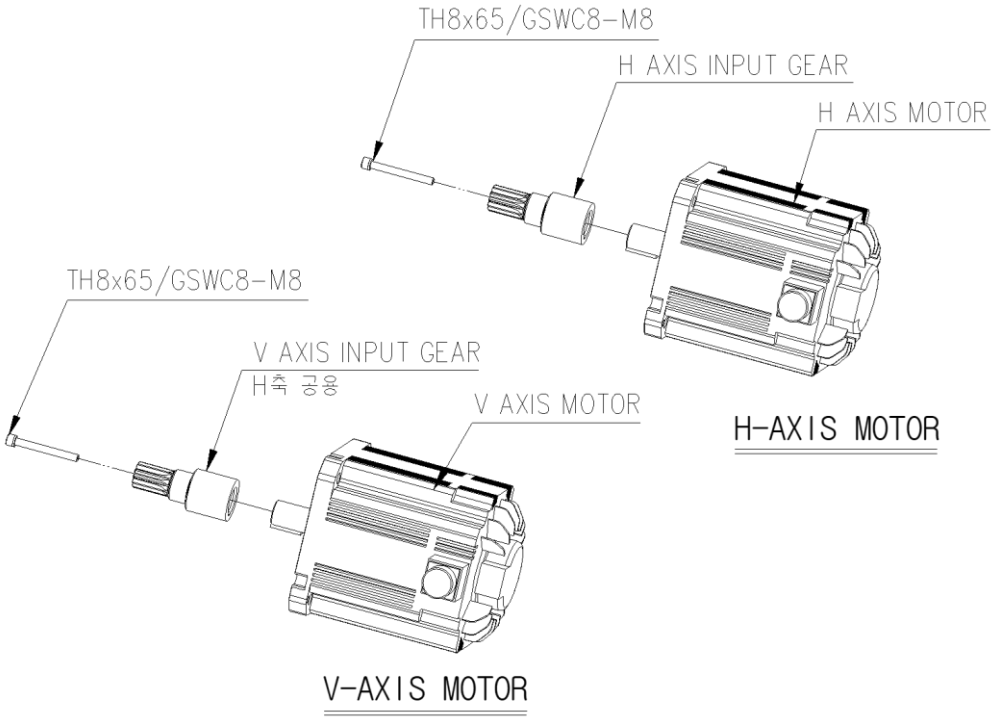


Figure 6.4 Motor assemblies of the H and V axes

Caution

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

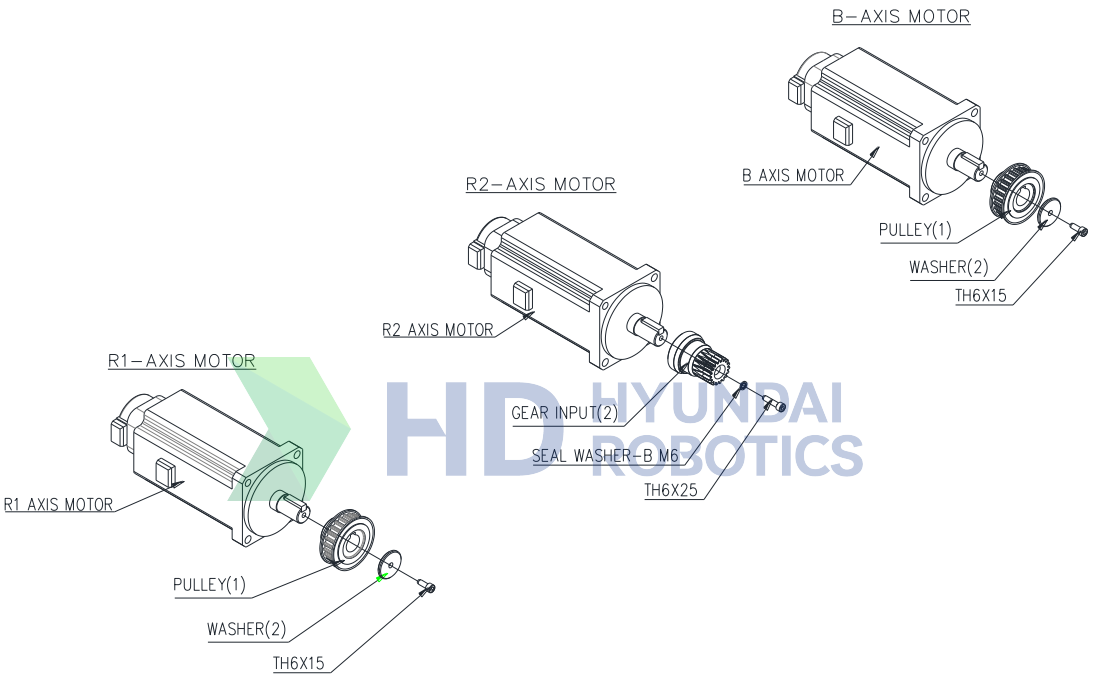


Figure 6.5 Motor assemblies of the wrist axes

6.5. Encoder Zero Setting

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

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

Waning

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

6.5.1. Zero Setting

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

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

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

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

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

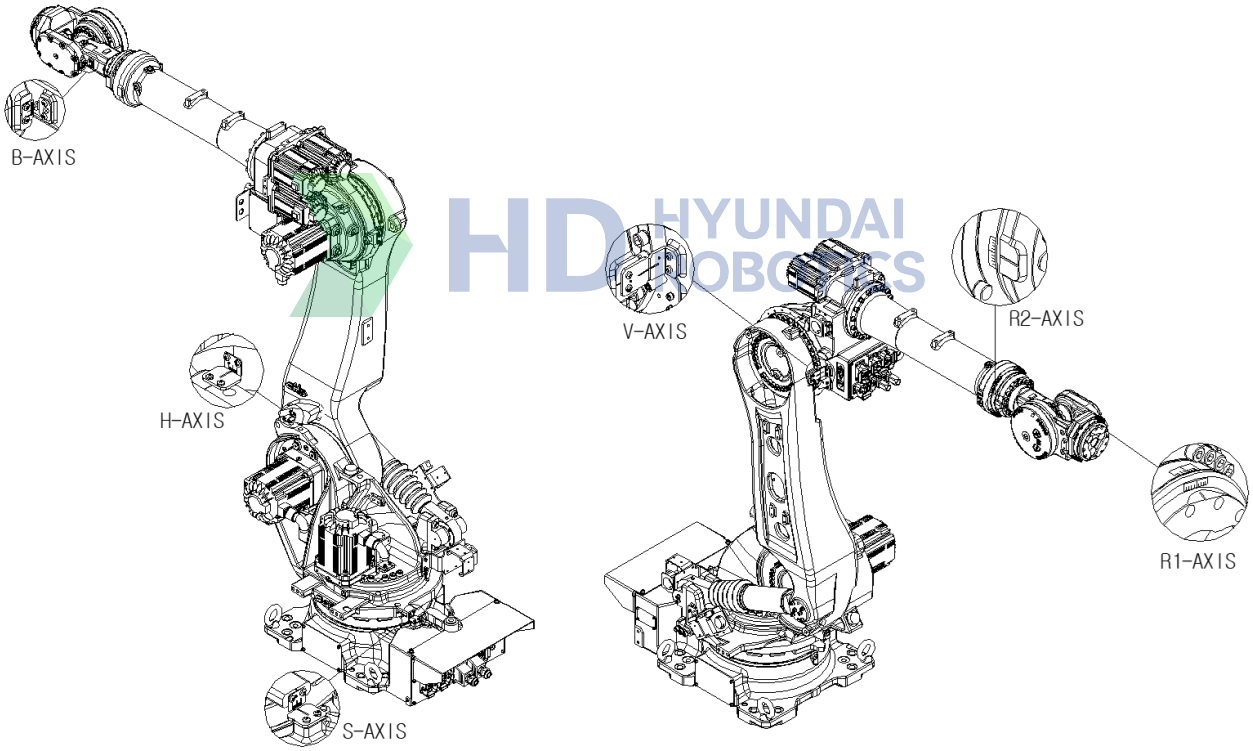
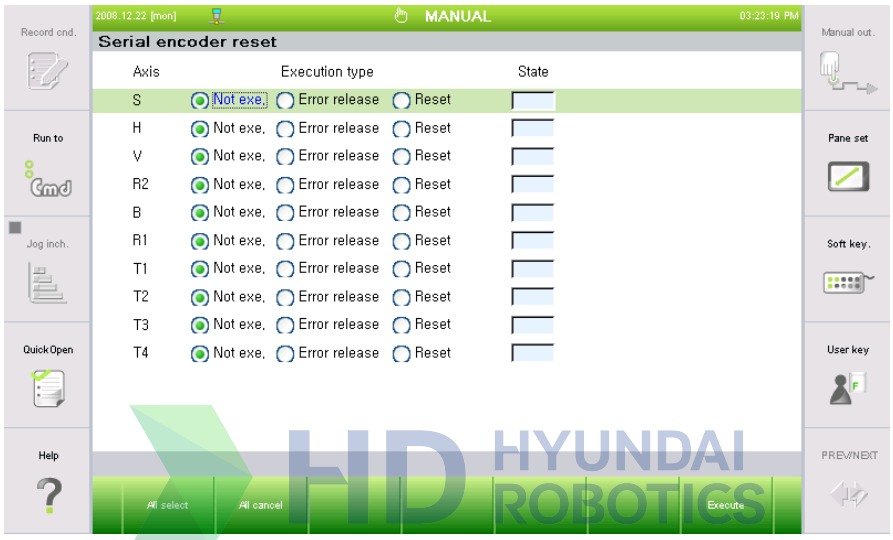


Figure 6.6 Method of Zero Setting

6.5.2. Encoder Reset

(1) Turn off the motor.

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



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

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

6.5.3. Encoder offset and Selection

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

[Encoder offset Screen]

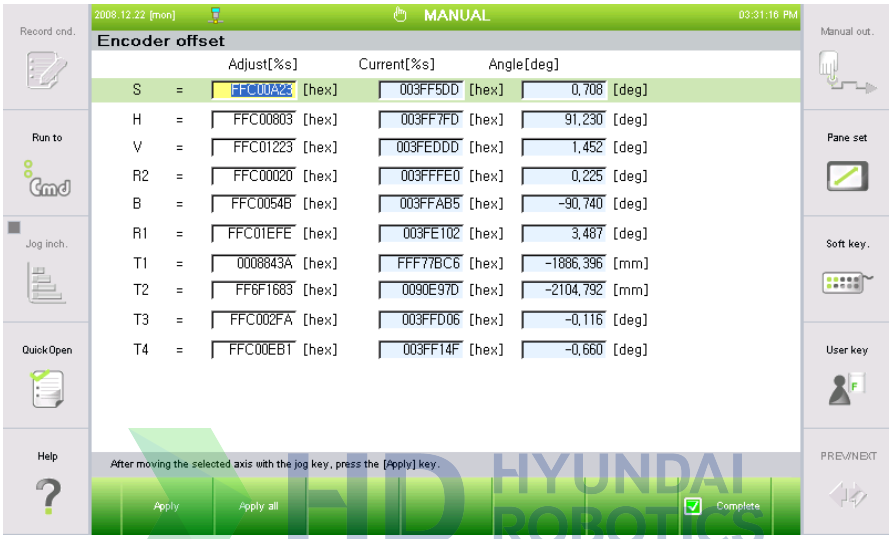


Table 6-5 Data range after the resetting

Axis	Data range after the resetting	Pulse count per rotation of the encoder
All axes	0 ~ 8,191	8,192

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

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

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

Warning

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

HYUNDAI ROBOTICS

7

Recommended Spare Parts

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

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

Table 7-1 Spare Parts List

Category	PLATE NO	Product Name and Specification	Quantity	Remark
A	R7900004400	GREASE VIGOGREASE RE0 1CAN=16KG	1	Common
A	R7900054780	GREASE GADUS S2 V46 2 (1CAN=15KG)	1	Common
A	R1001-6202-P02	ENCODER BATTERY	6	Common
B	RS3462-7081-0308	MOTOR	3	S/H/V-Axis
B	RS3462-7081-0335	MOTOR	3	R2/B/R-Axis
B	R3462-7082-0602	REDUCER	1	S-Axis
B	R3462-7082-0410	REDUCER	2	H/V-Axis
B	R3462-7082-0429	REDUCER	1	R2-Axis
B	R3462-7082-0510	REDUCER	1	B-Axis
B	R3462-7082-0512	REDUCER	1	R1-Axis
C	R3642-7412-001	WRIST ASSY	1	WRIST ASSY
C	R3462-7112-112	S-AXIS INPUT GEAR	1	For S-axis Motor
C	R3462-7212-113	INPUT GEAR(1)	2	For H/V-axis Motor
C	R3462-7312-337	GEAR INPUT(2)	1	For R2-axis Motor
C	R3462-7412-184	PULLEY(1)	2	For B/R1-axis Motor
C	R3462-7412-184	PULLEY(2)	1	For B-Axis reducer

Category	PLATE NO	Product Name and Specification	Quantity	Remark
C	R3462-7412-184	PULLEY(3)	1	For R1-Axis reducer
D	R3462-7112-P03	BALL BEARING	1	For S-Axis INPUT GEAR
D	R3462-7112-P04	OIL SEAL	1	LOWER FRAME
D	R3462-7112-P05	O-RING	1	For S-Axis motor
D	R3462-7112-P06	O-RING	1	BASE BODY
D	R3462-7112-P07	O-RING	1	For S-Axis reducer
D	R3462-7212-P03	OIL SEAL	2	For H/V-Axis INPUT GEAR
D	R3462-7212-P04	O-RING	2	For H/V-Axis motor
D	R3462-7212-P05	O-RING	2	For H/V-Axis reducer
D	R3462-7212-P06	O-RING	2	For H/V-Axis reducer
D	R3462-7312-P03	BALL BEARING	1	For R2-Axis INPUT GEAR
D	R3462-7312-P04	OIL SEAL	1	For R2-Axis INPUT GEAR
D	R3462-7312-P05	OIL SEAL	1	For R2-Axis reducer
D	R3462-7312-P06	O-RING	1	For R2-Axis reducer
D	R3462-7312-P07	O-RING	1	For R2-Axis motor
D	R3462-7312-P08	O-RING	1	HOLLOW(1)
D	R3462-7412-P05	BALL BEARING	1	For B-Axis reducer
D	R3462-7412-P06	BALL BEARING	1	GEAR INPUT(4)
D	R3462-7412-P07	BALL BEARING	1	HOUSING
D	R3462-7412-P08	BALL BEARING	2	GEAR INPUT(3)
D	R3462-7412-P09	BALL BEARING	2	ROLLER IDLER
D	R3462-7412-P10	TAPER ROLLER BEARING	2	HOUSING

Category	PLATE NO	Product Name and Specification	Quantity	Remark
D	R3462-7412-P11	TIMING BELT	2	PILLEY (1),(2),(3)
D	R3462-7412-P12	OIL SEAL	1	HOUSING
D	R3462-7412-P13	OIL SEAL	1	PULLEY(2)
D	R3462-7412-P14	OIL SEAL	1	WRIST BODY
D	R3462-7412-P15	OIL SEAL	1	For R1-Axis reducer
D	R3462-7412-P16	O-RING	1	For B-Axis reducer
D	R3462-7412-P17	O-RING	1	For R1-Axis reducer
D	R3462-7412-P18	O-RING	1	HOUSING
D	R3462-7412-P19	O-RING	1	COVER
D	R3462-7412-P20	O-RING	1	SHAFT GEAR
D	R3462-7412-P21	O-RING	1	For R1-Axis reducer
D	R3462-7230-002	GAS SPRING ASSY	1	GAS SPRING
D	R3462-7230-P02	SPHERICAL BEARING	1	GAS SPRING
D	R3462-7004-P01	LIMIT SWITCH	1	Option (S-Axis)
D	R3462-7004-P02	LIMIT SWITCH	2	Option (H/V-Axis)

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8 Dismantling

8. Dismantling

8.1. Materials of individual parts of the robot

The robot consists of several materials as shown in [Table 8-1]. In order to prevent adverse effects on the human body or the environment, some parts should be properly arranged and sealed.

Table 8-1 Table of materials for individual parts

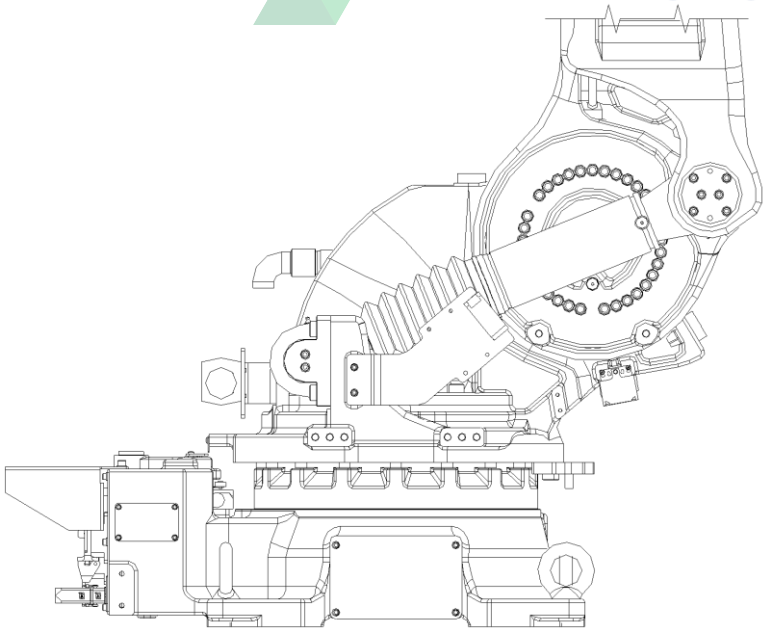
Parts	Materials
Battery	NiCad or Lithium
Wiring, Motor	Copper
Base body, Lower Frame, Upper Frame etc.	Cast Iron
Brakes, Motors	Samarium Cobalt(or Neodymium)
Wiring, Connectors	Plastic / Rubber
Reducers, Bearings	Oil / Grease
Wrist cover etc.	Aluminum alloy cast

8.2. Disposing of the gas spring assembly unit

Since the gas spring is assembled with a high compressive force, failure to observe the following procedure during disposal may cause personal injury and property damage. Be sure to follow the procedures.

8.2.1. Disconnecting the gas spring assembly unit

The H axis must be at the angle and posture as shown in [Figure 9.1] during the work of disconnecting the assembly unit. In this posture, the compressive force of the gas spring is minimized, allowing the assembly unit to be disconnected from the robot. Therefore, even if the gas spring assembly unit is disconnected from the main body, the compressive force will be kept in balance by the spring, helping minimize the risk factor during the disconnection process.
If the disconnection work is carried out to dispose of the gas spring or perform internal maintenance works, please carry out the disconnection work after completely removing the gas in compliance with the procedures of “9.3. Releasing the gas of the gas spring.”

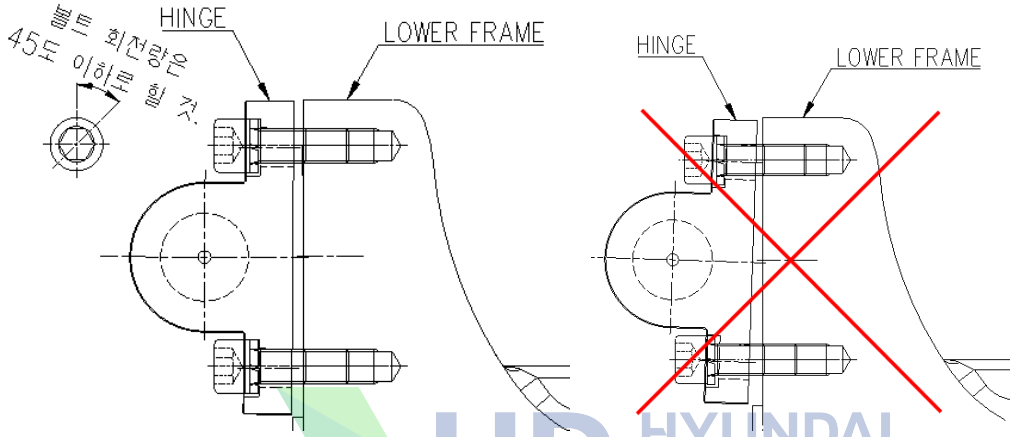


S- Axis	0
H- Axis	90
V- Axis	0
R2- Axis	0
B- Axis	0
R1- Axis	0

Figure 8.1 Posture for disconnecting the gas spring

Caution

- ✓ **When disconnecting and assembling the gas spring assembly unit, fasten or loosen the bolt of the hinge by rotating the bolt 45 degrees or less alternately between the upper and lower bolts so that the hinge will not be tilted excessively, as shown in the figure below. Excessive tilting of the hinge will cause damage to the bolt screws, and such a damaged bolt screw will damage the tap of the lower frame, making it difficult to perform the disconnecting and assembling process.**
- ✓ **The shape of each part such as hinge can be changed according to the mass production design.**



[Bolt rotation amount 45 degrees or below: Approved] [Bolt rotation amount 45 degrees or above: Not Approved]

8.2.2. Disposing of the gas spring assembly unit

The gas spring assembly unit disconnected from the main body still has a high compressive force inside itself. So, be sure to completely remove the gas according to the procedures of “9.3. Releasing the gas of the gas spring” and confirm that the pressure is removed completely before carrying the disposal work. In addition, some grease may be left inside, handle it in compliance with relevant regulations in an environment sensitive to contamination.

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9 Maintenance of the Gas Spring

Please manage the gas spring to keep its pressure at a proper level through periodic maintenance, and replace the gas spring when its pressure drops abnormally within a short period of time when taking into consideration the number of uses.

Caution

- ✓ Nitrogen gas filling is performed under high pressure. So, please comply with the safety regulations of the relevant country.
- ✓ Fill nitrogen gas only.
  (Never fill any other gas or liquefied nitrogen other than nitrogen gas)
- ✓ Be sure to wear protective glasses when working.
- ✓ Never look into the gas inlet or pressure gauge directly.
- ✓ If parts inside the gas spring are broken, secure safety by ensuring that any part of the human body or main facilities should not be placed in the direction of the operation of the gas spring, and then remove the gas completely. (When the internal parts are broken, they will bounce off at high speed due to the compressive force, causing a safety accident).
- ✓ Be sure to keep the H axis of the robot at 90 degrees (teaching pendant) when disconnecting the gas spring assembly unit. In that posture, the compressive force of the gas spring is minimized, making it possible to carry out the disconnection work (In other postures, the gas compressive force will be high, causing the bolt to bounce off at high speed during the disconnection process, resulting in a safety accident).
- ✓ For safety considerations and preservation of product performance, the internal parts of the gas spring should be disassembled and assembled only by using designated standard working tools and equipment, with appropriate training for and understanding of the product. Please contact us for related inquiries.
- ✓ Incorrect operation of / mistakes in using the measuring devices during gas pressure measurement may cause the gas pressure to drop. Please comply with the “9.1. Checking the gas spring pressure.”
- ✓ Before checking the gas spring, be sure to check whether the controller and external powers are in the 『OFF』 state. Also, take measures to prevent the controller and external powers from being turned 『ON』 accidentally by other people.
- ✓ Replace the bearings also when replacing old gas springs.
  Inject grease regularly into the bearing part of the gas spring.
  (Every 6 months. Every 3 months under severe conditions)
- ✓ Include the specification of the nitrogen gas bottle connection screw when purchasing gas injection parts.

9.1. Checking the gas spring pressure

(1) Set the H axis of the robot at the 90 ° posture, and cut off the power to the controller.
(2) Remove the plug installed in the gas inlet of the spring.
(3) Check if the handle Ⓟ is locked (Clockwise lock).
(4) Check if the gas release pin Ⓡ is protruding. If it is protruding, turn the handle Ⓞ counterclockwise so that the pin does not protrude.
(5) Turn the base handle Ⓝ of the pressure tester clockwise to connect it to the gas inlet completely.
(6) Slowly turn the Ⓞ handle clockwise until the pressure gauge reading indicates the pressure range (do not turn the Ⓞ handle excessively. Otherwise, the gas release pin Ⓡ will go inwards excessively, damaging the value inside the gas spring.
The gas pressure according to the surface temperature of the gas spring is as shown in the table below.
(7) After the pressure is checked, turn the handle Ⓞ counterclockwise to retract it, and then turn the handle Ⓟ counterclockwise to release the residual gas inside the tester.
(8) Turn the base handle Ⓝ of the pressure tester counterclockwise to disconnect it and mount the plug again.

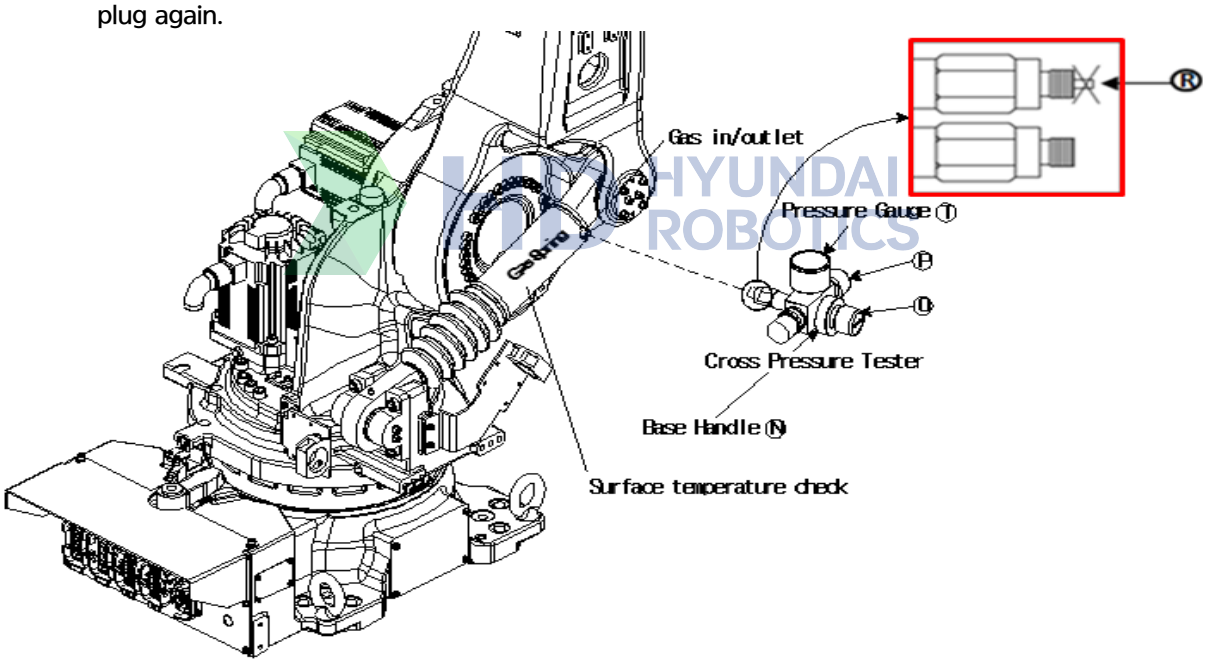


Figure 9.1 Checking the gas spring pressure

Table 9-1 Table of the pressure for each surface temperature of the gas spring]

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

Upon each gas pressure measurement, the pressure will drop approximately 0.5 bar. Depending on its type, the cross pressure tester may have a different name and its handle position may be different. Please refer to the manual enclosed together when purchasing the tester.

9.2. Replenishing the gas for the gas spring

Caution

- ✓ **Nitrogen gas filling is performed under high pressure. So, please comply with the safety regulations of the relevant country.**
- ✓ **Fill nitrogen gas only.**
  (Never fill any other gas or liquefied nitrogen other than nitrogen gas)
- ✓ **Be sure to wear protective glasses when working.**
- ✓ **Never look into the gas inlet or pressure gauge directly.**
- ✓ **Replenishing and filling the gas must be performed after the gas spring is assembled to the robot.**
- ✓ **Once the gas is filled, please use it after waiting for about 30 minutes for the temperature to return to the level of room temperature.**
- ✓ **Before checking the gas spring, be sure to check whether the controller and external powers are in the 『OFF』 state. Also, take measures to prevent the controller and external powers from being turned 『ON』 accidentally by other people.**

9.2.1. When the nitrogen gas bottle pressure exceeds 150 bar

(1) Set the H axis of the robot at the 90 ° posture, and cut off the power to the controller
(2) Remove the plug installed in the gas inlet of the spring.
(3) Make sure that the bleed value ⑫ and shutoff value ⑨ of the charging armature are closed (clockwise lock)
(4) Turn the knob ⑩ counterclockwise to prevent the release pin ⑧ from being protruding.
(5) Turn the knob ⑬ of the pressure tester (= armature) clockwise to connect it to the gas inlet completely.
(6) Check whether the valve ⑪ is closed.
(7) Connect the regulator connection part screw to the nitrogen gas bottle screw.
If the gas bottle pressure is 150 bar or below, the booster should be mounted, in addition to the regulator (conditions for the nitrogen gas bottle that can be used to fill the gas without a booster: The pressure of the gas bottle should be 150 or above and the bottle should have the capacity to fill the gas spring with the gas with a pressure of 140 bar).
(8) The gauge ⑥ indicates the target gas pressure and the gauge ⑦ indicates the gas bottle pressure.
(9) Open the knob ② of the nitrogen gas bottle and turn the handle ① of the regulator (⑦) to set the target gas pressure (the target gas pressure is designated in the “Table 9-1 Table of the pressure for each surface temperature of the gas spring”).
(10) Fill the gas up to the target pressure by opening the shutoff value ⑨ slowly.
(11) If the target pressure is reached, close the shutoff valve ⑨ and open the bleed value ⑫ to release the residual pressure inside the pressure tester (armature).
Do not loosen the bleed value ⑫ by turning it 360 ° or more.
(12) Close the bleed valve ⑫ to adjust the gas pressure of the gas spring.
(13) Check the pressure of the pressure gauge ⑪ by turning the knob ⑩ clockwise slowly.
Take precautions not to let the release pin ⑧ to go inwards excessively, causing damage to the valve mounted to the gas spring.
(14) If the gas pressure is too high, adjust the gas pressure to the desired level by opening and closing the bleed valve ⑫ slightly.

(15) Bring the release pin ⑱ back to its original position by turning the knob ⑰ counterclockwise.

(16) When the pressure is checked, check whether the shutoff value ⑰ is closed, and then open the bleed valve ⑯ to completely release the residual pressure inside the pressure tester (= armature).
(17) Lock the knob ⑫ of the nitrogen gas bottle and loosen the regulator connection part to disconnect it from the gas bottle.
(18) Loosen the shutoff connection part to disconnect it from the pressure tester (armature).
(19) Turn the knob ⑭ of the pressure tester (= armature) counterclockwise to disconnect it from the gas spring.
(20) Check the check valve of the gas spring for oil or gas leaking.
Warning! Do not look directly into the check valve hole if the gas bottle is filled with gas.
(21) Fasten the G1/8 plug to the gas spring.
Once the gas is filled, please use it after waiting for about 30 minutes for the temperature to return to the level of the room temperature.

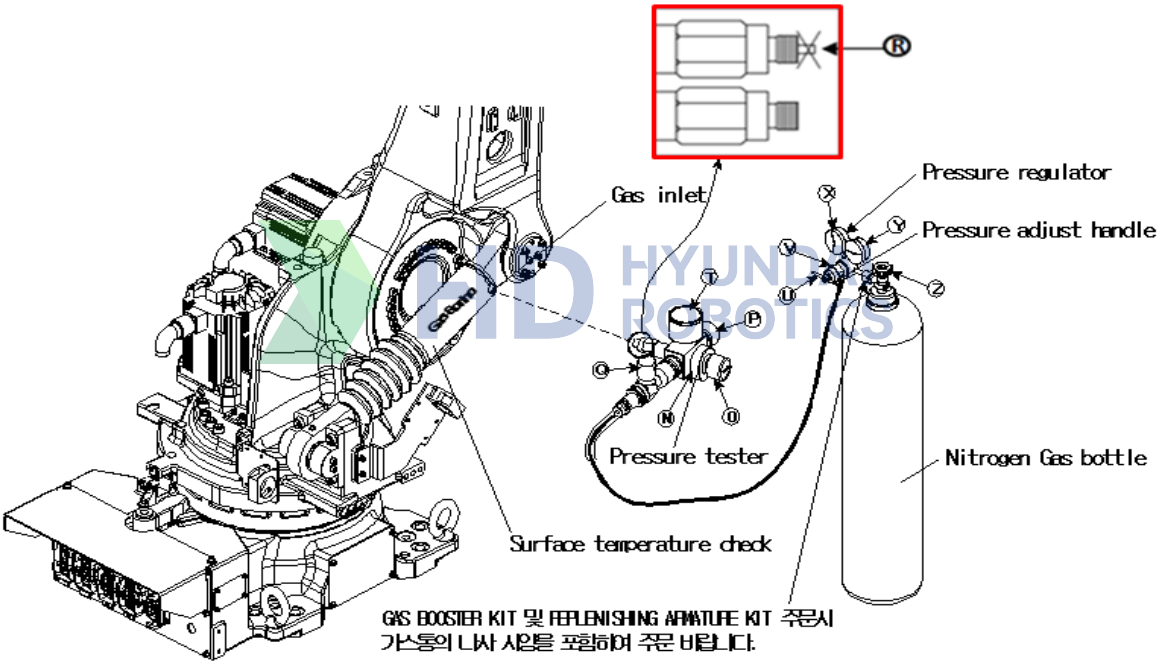


Figure 9.2 Replenishing the gas spring with the gas

Depending on the type, the gas replenishing kit may have a different name and its handle position may vary. Please refer to the manual enclosed when purchasing the kit.
When it is necessary to replenish or fill the gas by using the booster, please refer to the manual enclosed when purchasing the kit.

9.2.2. When the nitrogen bottle pressure is 150 bar or below (Replenishing the gas by using the booster)

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

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

(3) Check if the bleed value ⑫ and shutoff valve ⑨ of the pressure tester are closed (Clockwise lock).

(4) Turn the knob ⑥ counterclockwise so that the release pin ⑧ does not protrude.

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

(6) Check whether the handle ⑪, shutoff valve ⓦ, knob ⓢ (the knob of the air hose owned by the customer), and the shutoff valve are closed.

(7) Connect the regulator connection part screw to the nitrogen bottle screw.
(Each connection part of the hoses should be connected to each connection inlet)
Since the specification of the nitrogen bottle screw varies among countries, be sure to purchase a regulator that can meet the specification of the nitrogen bottle screw.

(8) The gauge ⑩ indicates the target gas pressure of the nitrogen bottle, and the gauge ⑭ indicates the pressure of the nigrogen bottle.

(9) Open the knob ② of the nitrogen bottle and turn the handle of the regulator to set the target gas pressure (The targe gas pressure is the designated in the “Table 9-1 Table of the pressure for each surface temperature of the gas spring”).

(10) Open the shutoff valve ⓦ of the hose connected to the regulator ⑬, and turn the shutoff value ⑨, which is to be connected to the pressure tester, counterclockwise slowly until the pointer of the pressure gauge ⑦ and the pointer of the gauge ⑩ are matching.

(11) Connect the air hose connection part to the booster, and then open the knob ⓢ (the knob of the air hose owned by the customer). Then, the booster will operate.
Fill the gas until the pointer of the pressure gauge ⑦ reaches the target pressure.
※ The minimum air pressure for the filling process is 5 bar or higher.
Replace the nitrogen bottle when the residual pressure of the bottle is below 30 bar or lower.

(12) If the target pressure is reached, close the shutoff valve ⑨ and open the bleed valve ⑫ to release the residual pressure inside the pressure tester.
(Do not loosen the bleed value ⑫ by turning it 360 ° or more)

(13) Close the bleed valve ⑫. While turning the knob ⑨ clockwise slightly, check whether the pointer of the pressure gauge ⑦ matches with the target pressure. If it is confirmed that they are matching, stop turning it.
Take precautions not to let the release pin ⑧ go inwards excessively, causing damage to the valve mounted to the gas spring.

(14) If the pressure exceeds the target pressure, adjust the gas pressure to the desired level by opening and closing the bleed valve Ⓟ slightly.

(15) Turn the knob Ⓞ counterclockwise to retract the release pin Ⓡ.

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

(17) Lock the knob Ⓢ of the air hose and disconnect it from the booster.

(18) Close the shutoff valve Ⓦ of the hose connected to the regulator and lock the handle Ⓤ.

(19) Lock the knob Ⓩ of the nitrogen bottle and disconnect the hose connected to the regulator Ⓥ from the booster and open the shutoff valve Ⓦ to release the residual pressure inside.

(20) Disconnect the shutoff connection part from the pressure tester.

(21) Turn the knob Ⓝ of the pressure tester counterclockwise to disconnect it from the gas spring. Fasten the G1/8 plug to the gas spring.
Once the gas is filled, please use it after waiting for about 30 minutes for the temperature to return to the level of the room temperature.

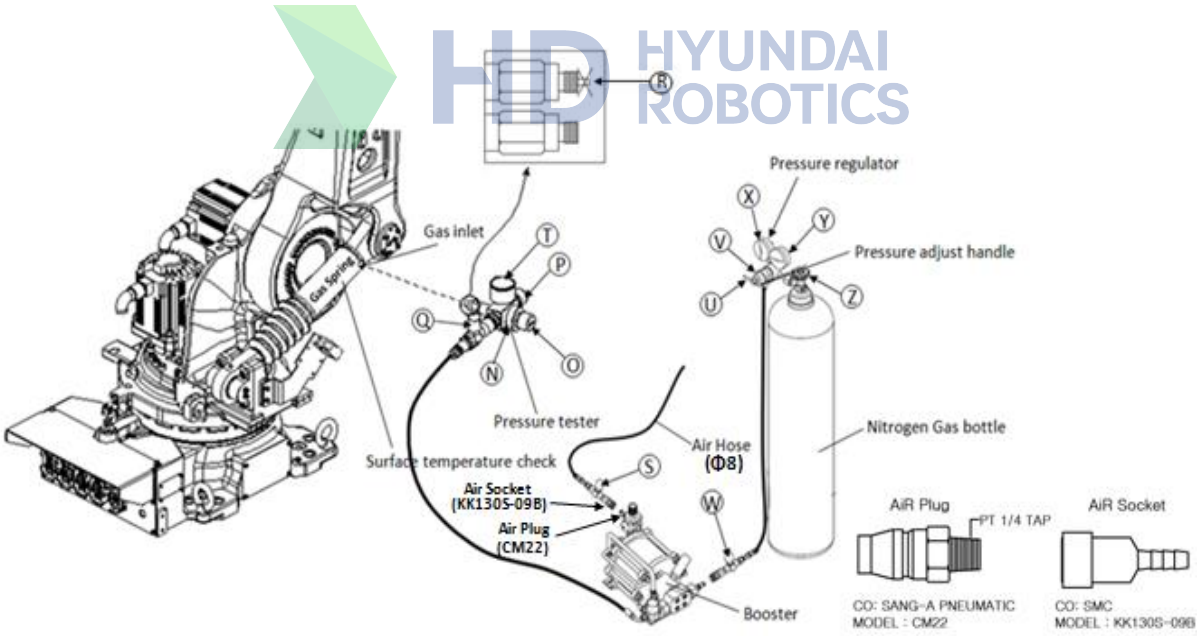


Figure 9.3 Replenishing the gas of the gas spring by using the booster

Depending on the type, the gas replenishing kit and the booster may have a different shape and name. Please refer to the manual enclosed when purchasing the kit

9.3. Releasing the gas for the gas spring

The gas of the gas spring is released in the following cases.
- When the gas spring needs to be disconnected from the robot, but it is impossible to set the H axis at the 90° posture because the H axis does not operate.
- When transporting robots by air. (It is regulated by law that air transport of machinery with high-pressure equipment should be performed after the pressure is removed.)

Caution
If the gas is released abruptly, colored oil inside the spring may be ejected. Make sure that the gas can be released slowly.

(1) Remove the plug installed in the gas inlet of the spring.
(2) Check if the handle Ⓟ is locked (clockwise lock)
(3) Check if the gas release pin Ⓡ is protruding. If it is protruding, turn the handle Ⓞ counterclockwise so that the pin does not protrude.
(4) Turn the base handle Ⓝ of the pressure tester clockwise to connect it to the gas inlet completely.
(5) Slowly turn the handle Ⓞ clockwise until the pressure gauge reading indicates the pressure range (Do not turn the Ⓞ handle excessively. Otherwise, the gas release pin Ⓡ will go inwards excessively, damaging the value inside the gas spring).
(6) Turn the gas release handle Ⓟ counterclockwise slowly to release the gas completely.
Warning! Never look into the gas outlet hole directly.
(7) Turn the handle Ⓞ counterclockwise to retract the release pin, and then turn the base handle Ⓝ of the pressure tester counterclockwise to disconnect it
(8) Fasten the G1/8 plug to the gas spring.

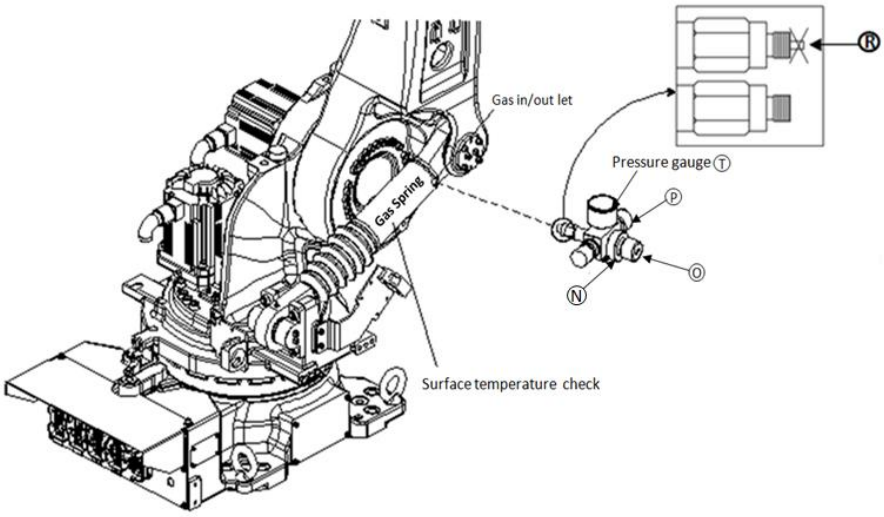


Figure 9.4 Releasing the gas of the gas spring

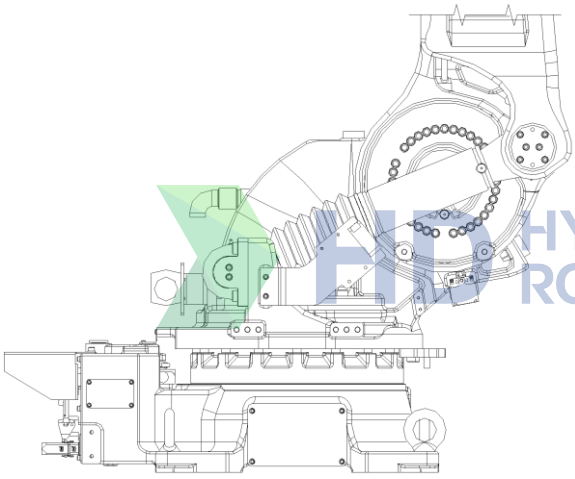
9.4. Replacing the assembly unit of the gas spring (disconnecting and assembling)

When replacing the gas spring assembly unit, please replace the bearings assembled to the BS joint.

9.4.1. Disconnecting the gas spring assembly unit

The H axis must be at the angle and posture as shown in [Figure 9.1] during the work of disconnecting the assembly unit. In this posture, the compressive force of the gas spring is minimized, allowing the assembly unit to be disconnected from the robot. Therefore, even if the gas spring assembly unit is disconnected from the main body, the compressive force will be kept in balance by the spring, helping minimize the risk factor during the disconnection process

However, when it is needed to carry out the disconnection work to dispose of the gas spring or perform internal maintenance works but it is impossible to set the H axis at the 90° posture because the H axis does not operate, please completely remove the gas in compliance with “9.3. Releasing the gas of the gas spring.”

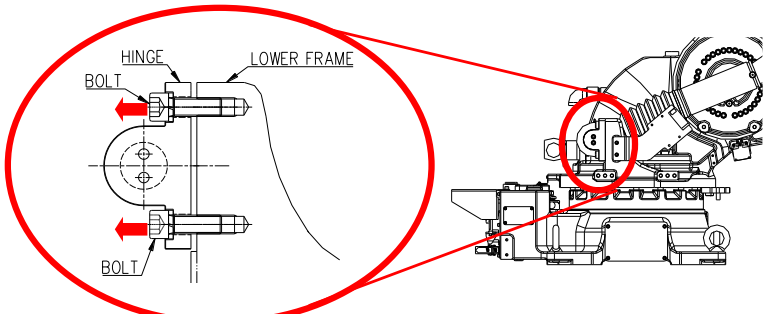


H- Axis	90 °

Figure 9.5 Posture for disconnecting the gas spring

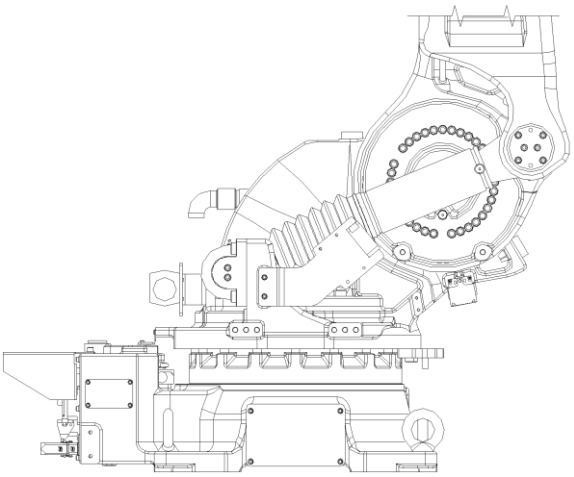
[Danger]

- ✓ **Postures at which the disconnection of the gas spring assembly unit must not be performed: H axis is at other degrees than at 90 °**
  (If the H axis is at other postures than at 90 ° , the compressive force of the gas spring will be excessive, meaning that if the hinge bolts are loosened, the thread of the screw will be broken by the pressure of the gas spring, and the bolt will be bounced off at high speed, causing accidents involving people or damage to the equipment).



9.4.2. Assembling the gas spring assembly unit

The H axis must be at the angle and posture as shown in [Figure 9.6] during the work of assembling the assembly unit. In this posture, the compressive force of the balance spring is minimized, making it possible to assemble the robot.

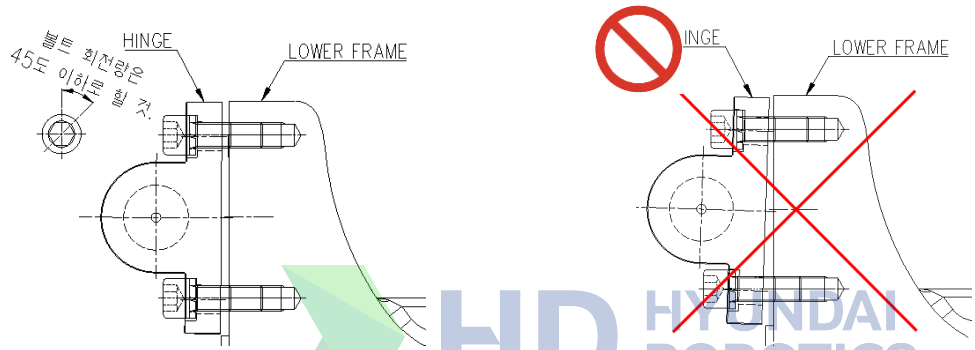


S- Axis	0
H- Axis	90
V- Axis	0
R2- Axis	0
B- Axis	0
R1- Axis	0

Figure 9.6 Posture for assembling the gas spring

Caution

- ✓ When disconnecting and assembling the gas spring assembly unit, fasten or loosen the bolt of the hinge by rotating the bolt 45 degrees or less alternately between the upper and lower bolts so that the hinge will not be tilted excessively, as shown in figure 9.7 below.
- ✓ Excessive tilting of the hinge will cause damage to the bolt screws, and such a damaged bolt screw will damage the tap of the lower frame, making it difficult to perform the disconnecting and assembling process.
- ✓ The shape of each part such as hinge can be changed according to the mass production design.



[Bolt rotation amount 45 degrees or below: Approved] [Bolt rotation amount 45 degrees or above: Not Approved]

Figure 9.7 Cautions in fastening/loosening the gas spring hinge bolts

9.4.3. Technical data of the gas spring

Table 9-2 Technical data of the gas spring

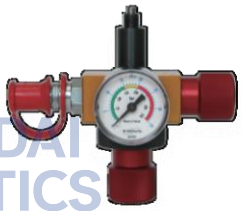
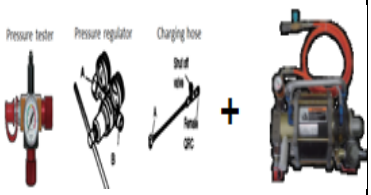
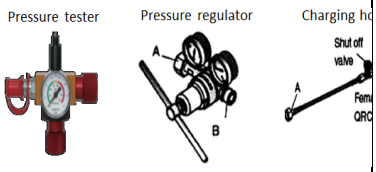
Classification	Data	Remarks
Pressure medium	Nitrogen gas / Hydraulic oil	
Stroke length	160mm	
Operation temperature	0 ℃ ~ 80 ℃	
Gas volume	0.9 liter	
Maximum filling pressure	140 bar	
Proper working pressure	140 bar ~ 125 bar	Target pressure for maintenance and management
Minimum allowable pressure	105 bar	
Weight	About 14 kg	

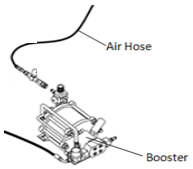
※ For the pressures, refer to the “Table 9-1 Table of the pressure for each surface temperature of the gas spring.”

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

9.4.4. Parts for measuring the gas spring pressure and for filling the gas

Table 9-3 Parts for measuring the gas spring pressure and for filling the gas

Part name and specification	Plate No.	Quantity per unit	Shape	Type of supply
GAS SPRING & BS JOINT & BELLOWS(1) & Nipple	R3462-7230-001(1)	1		Hyundai Robotics (Option)
Bearing Collar	R3462-7230-218	2		
Spherical Bearing 22208	R3462-7230-P02	2		
Nilos Ring 22208JV	R3462-7230-P03	4		
PRESSURE TESTER-1 (For measuring the pressure)	R3462-7230-R01	1		Hyundai Robotics (Option)
REPLENISHING ARMATURE KIT-1 + GAS BOOSTER KIT-1 1. For filling the gas when the nitrogen bottle pressure is 150 bar or below 2. Item to be included when the customer places an order : Specification of the nitrogen bottle connection part screw	R3462-7230-R05 + R3462-7230-R03	1		Hyundai Robotics (Option)
REPLENISHING ARMATURE KIT-1 1. For filling the gas when the nitrogen bottle pressure exceeds 150 bar 2. Item to be included when the customer places an order : Specification of the nitrogen bottle connection part screw	R3462-7230-R05	1		Hyundai Robotics (Option)
GAS BOOSTER KIT-1 1. For boosting the pressure when the nitrogen bottle pressure is 150 bar or below 2. AIR INLET PLUG MALE : R1/4 3. Item to be included when the customer places an order : Specification of the nitrogen bottle connection part screw	R3462-7230-R03	1		Hyundai Robotics (Option)

Air Hose and quick coupling (for supplying air)	-	1		Customer

HYUNDAI ROBOTICS

10 Internal Wiring Diagram

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

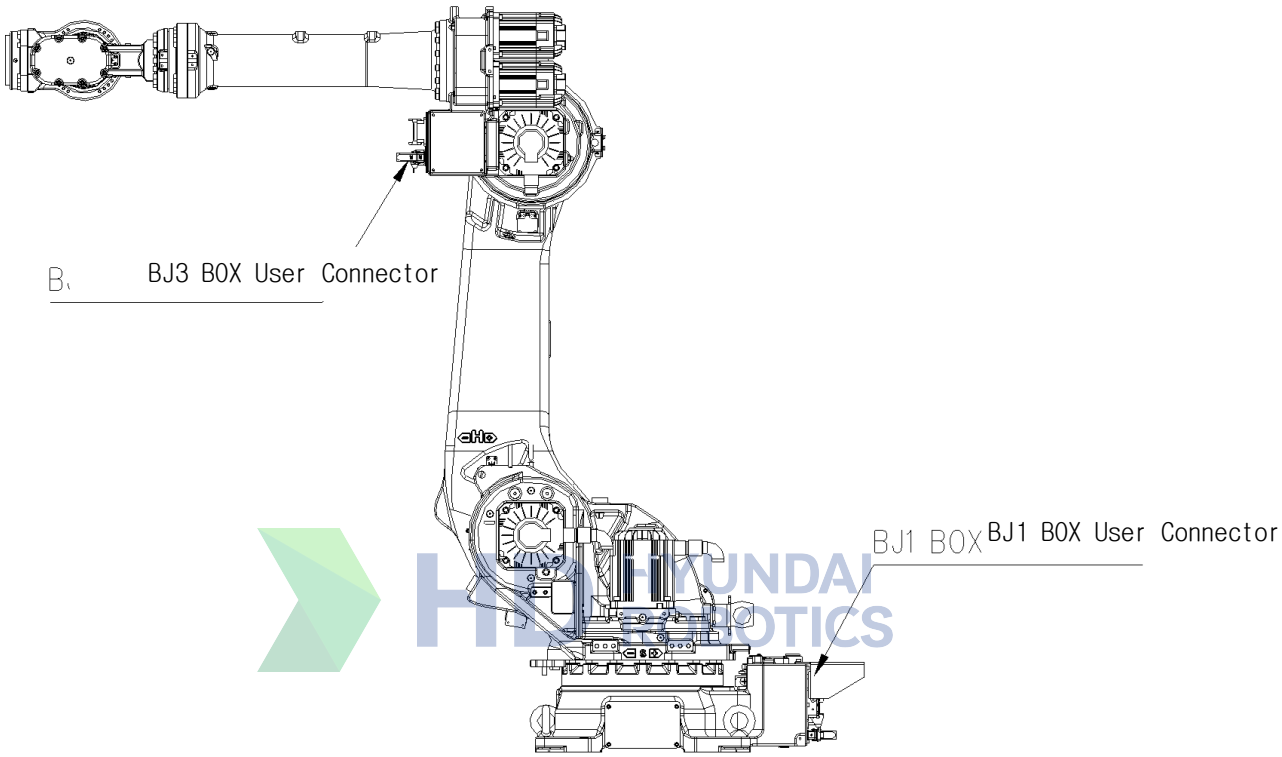
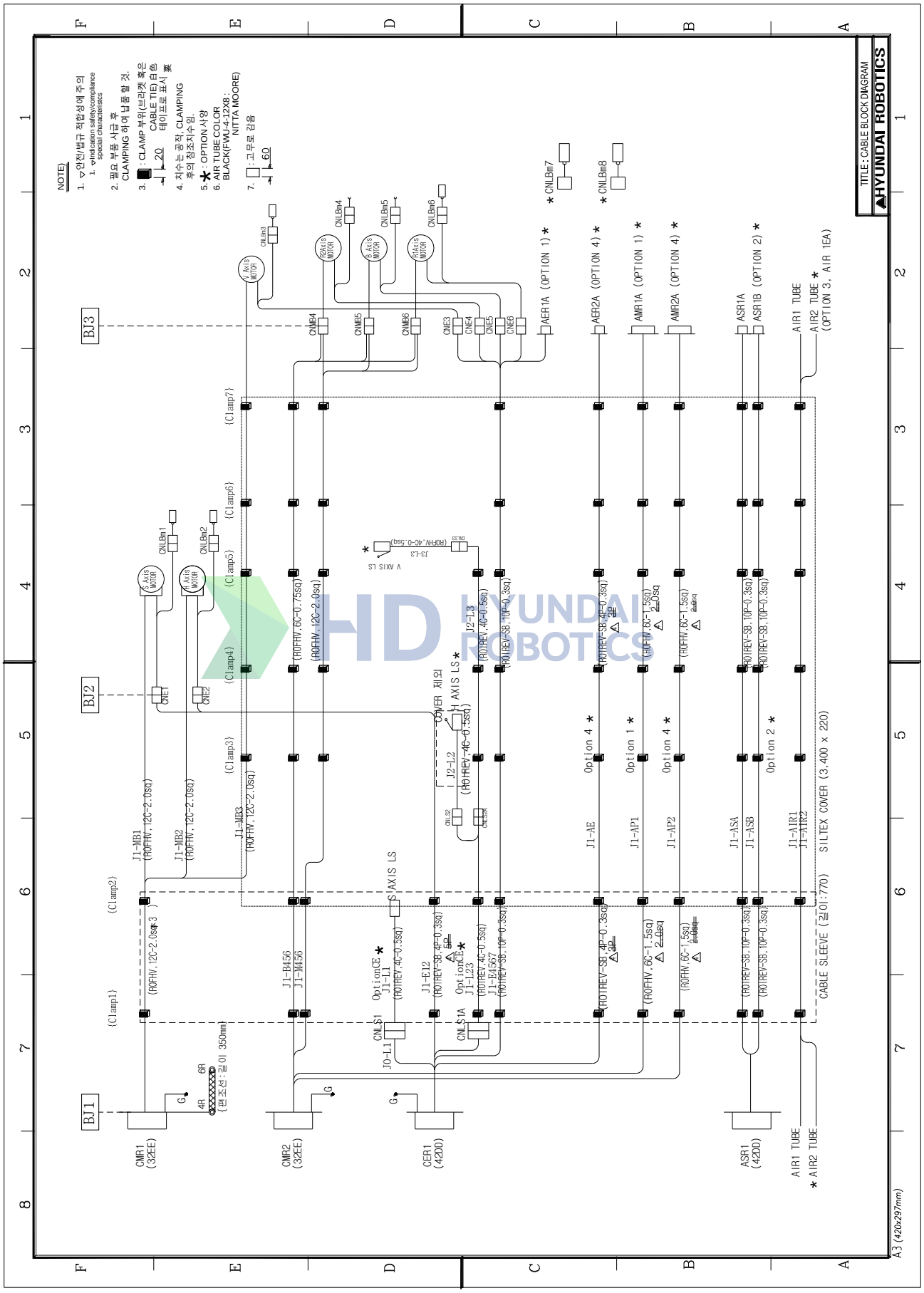


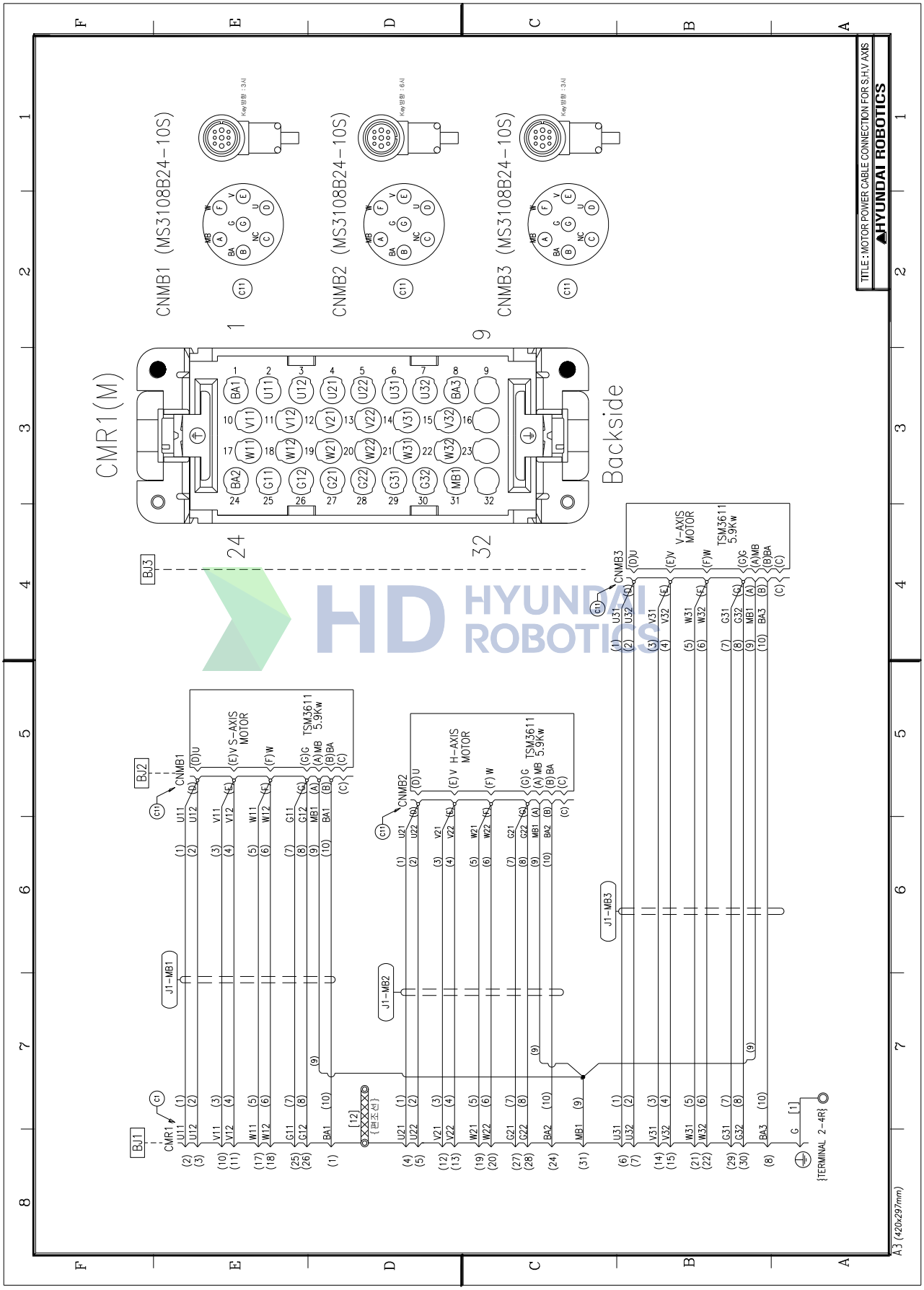
Figure 10.1 Manipulator Configuration

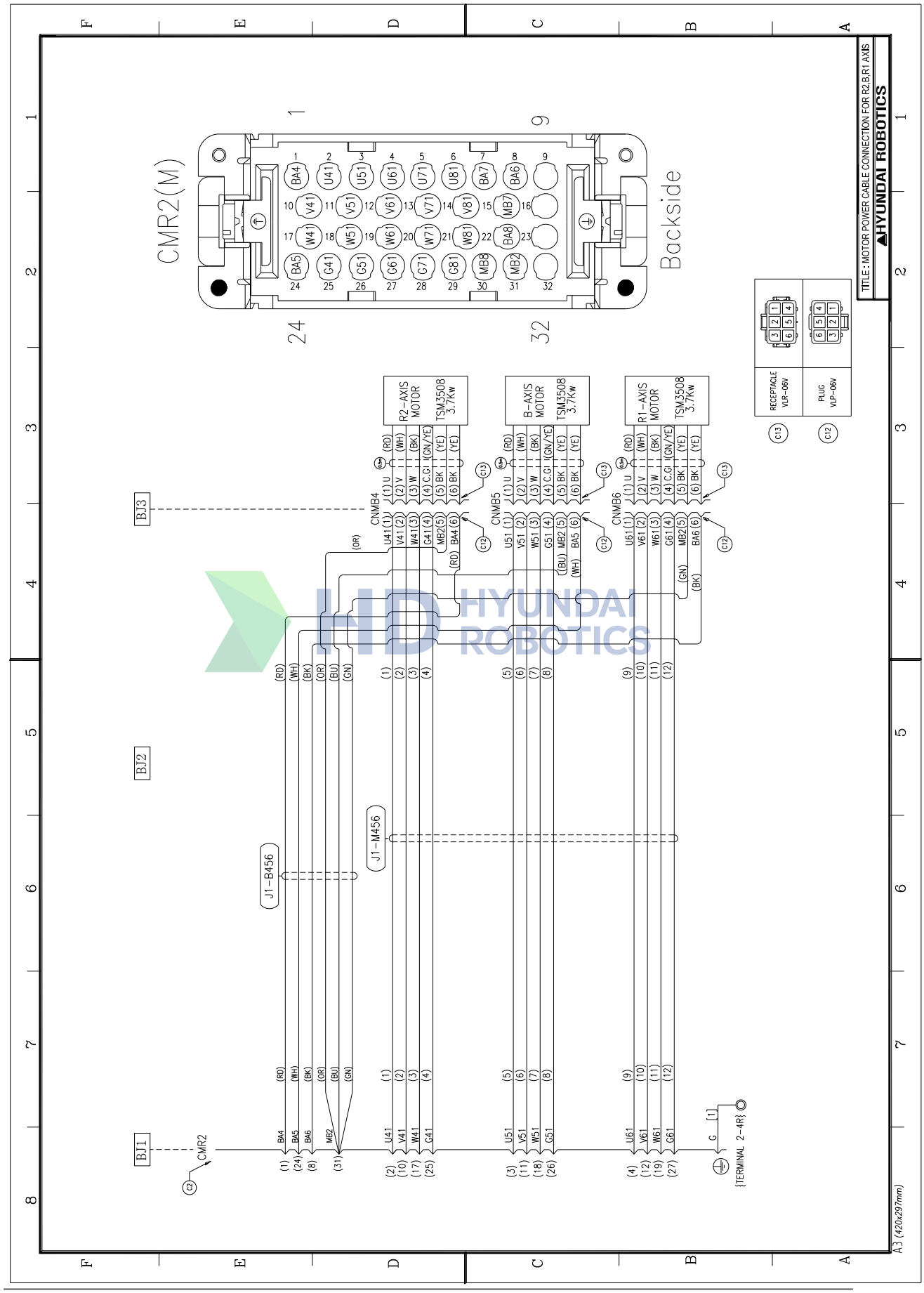
HS220 SERIE Internal wiring diagram

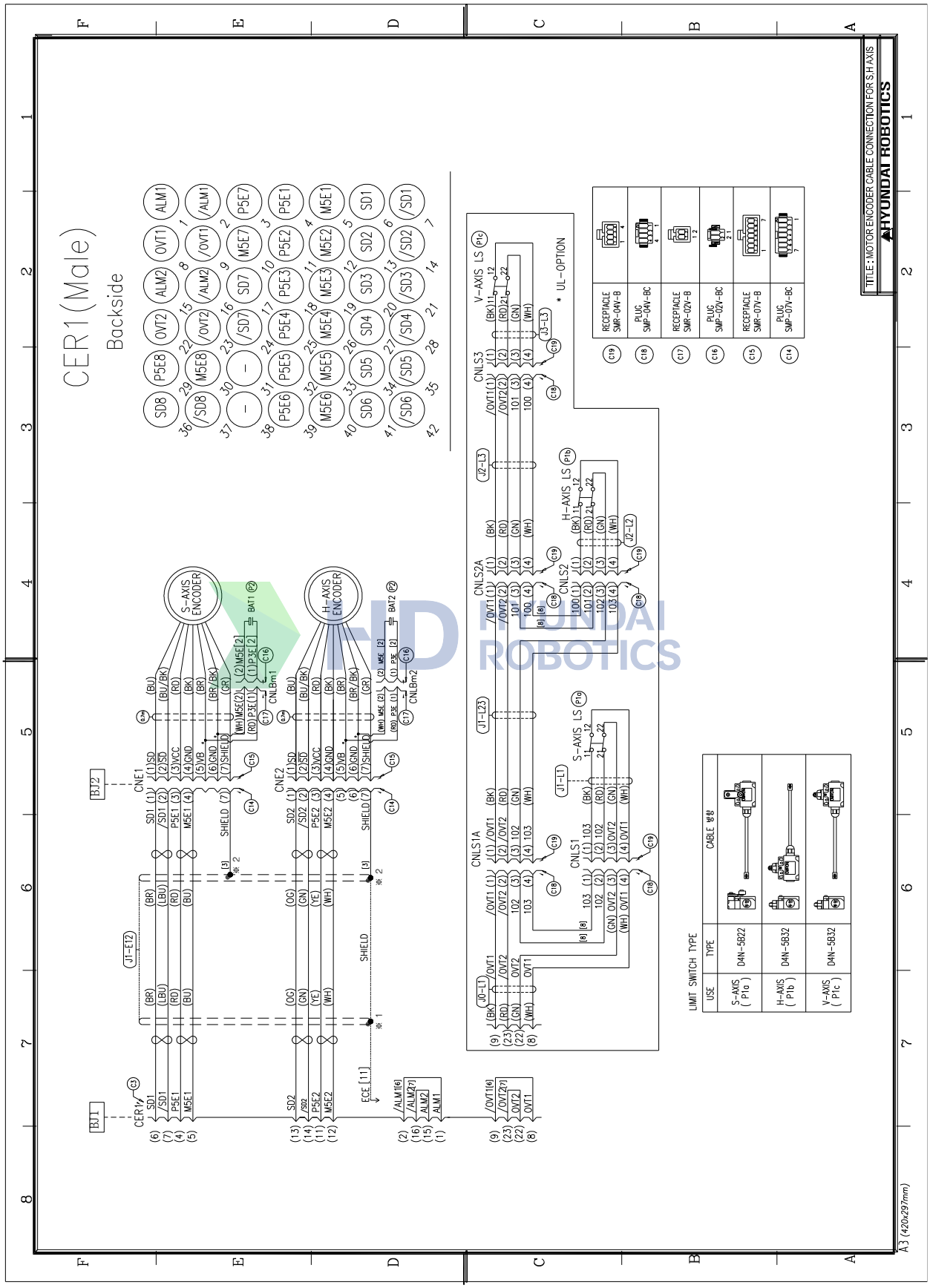
HYUNDAI ROBOTICS

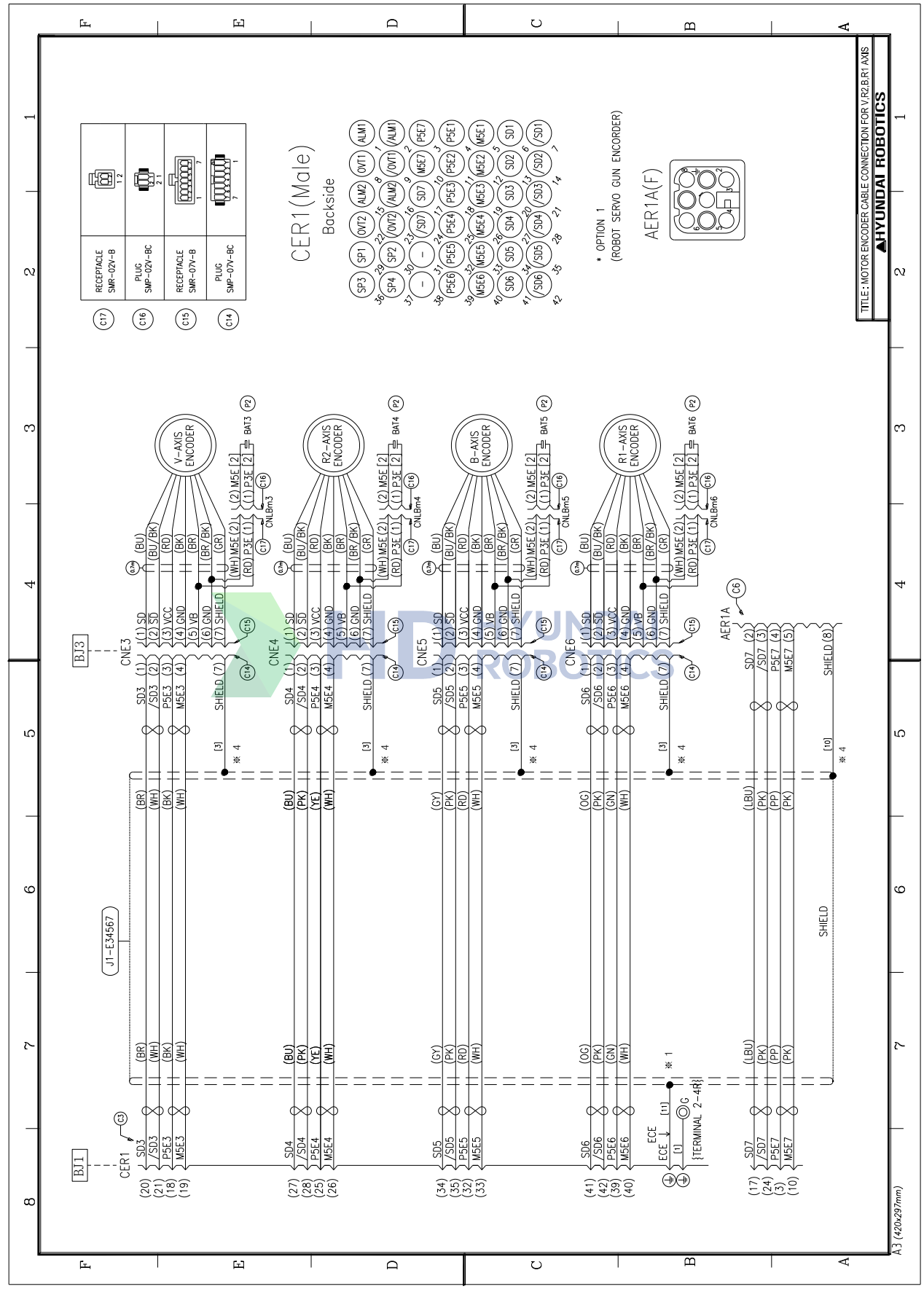
A3 (420x297mm)

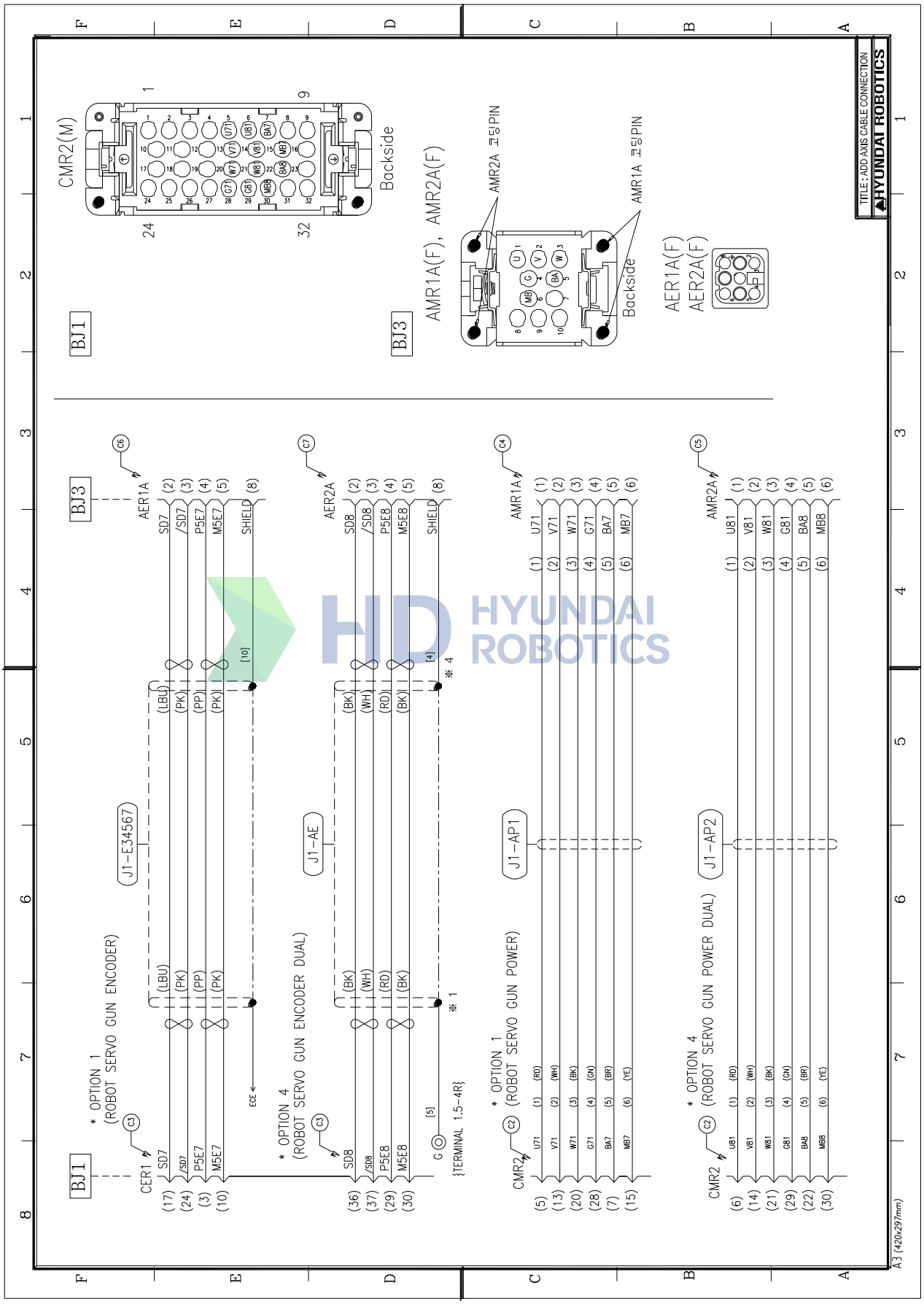

TITLE : CABLE BLOCK DIAGRAM
HYUNDAI ROBOTICS
NOTE)
1. 수인자/법규 적합성에 주의
1. y-indication safety/compliance special characteristics
2. 필요 부품 사급 후 CLAMPING 하여 납품 할 것.
3. : CLAMP 부위(브라켓 혹은 CLAMPING 하여 납품 할 것. CABLE TIE) 白色 테이프로 표시 要
4. 치수는 공작, CLAMPING 후의 참조치수 임.
5. * : OPTION 사양
6. AIR TUBE COLOR BLACK(FWU-4-12X8 : NITTA MOORE)
7. : 고무로 감쌈
BJ1
BJ2
BJ3
CMR1 (32EE)
CMR2 (32EE)
CER1 (42DD)
ASR1 (42DD)
AIR1 TUBE
* AIR2 TUBE
CABLE SLEEVE (길이:770)
SILTEX COVER (3,400 x 220)
AER1A (OPTION 1) *
AER2A (OPTION 4) *
AMR1A (OPTION 1) *
AMR2A (OPTION 4) *
ASR1A
ASR1B (OPTION 2) *
AIR1 TUBE
AIR2 TUBE * (OPTION 3, AIR 1EA)
* CNLBm7
* CNLBm8
Option 4 *
Option 1 *
Option 4 *
Option 2 *
* AXIS LS
V AXIS LS
COVER 제외
A3 (420x297mm)

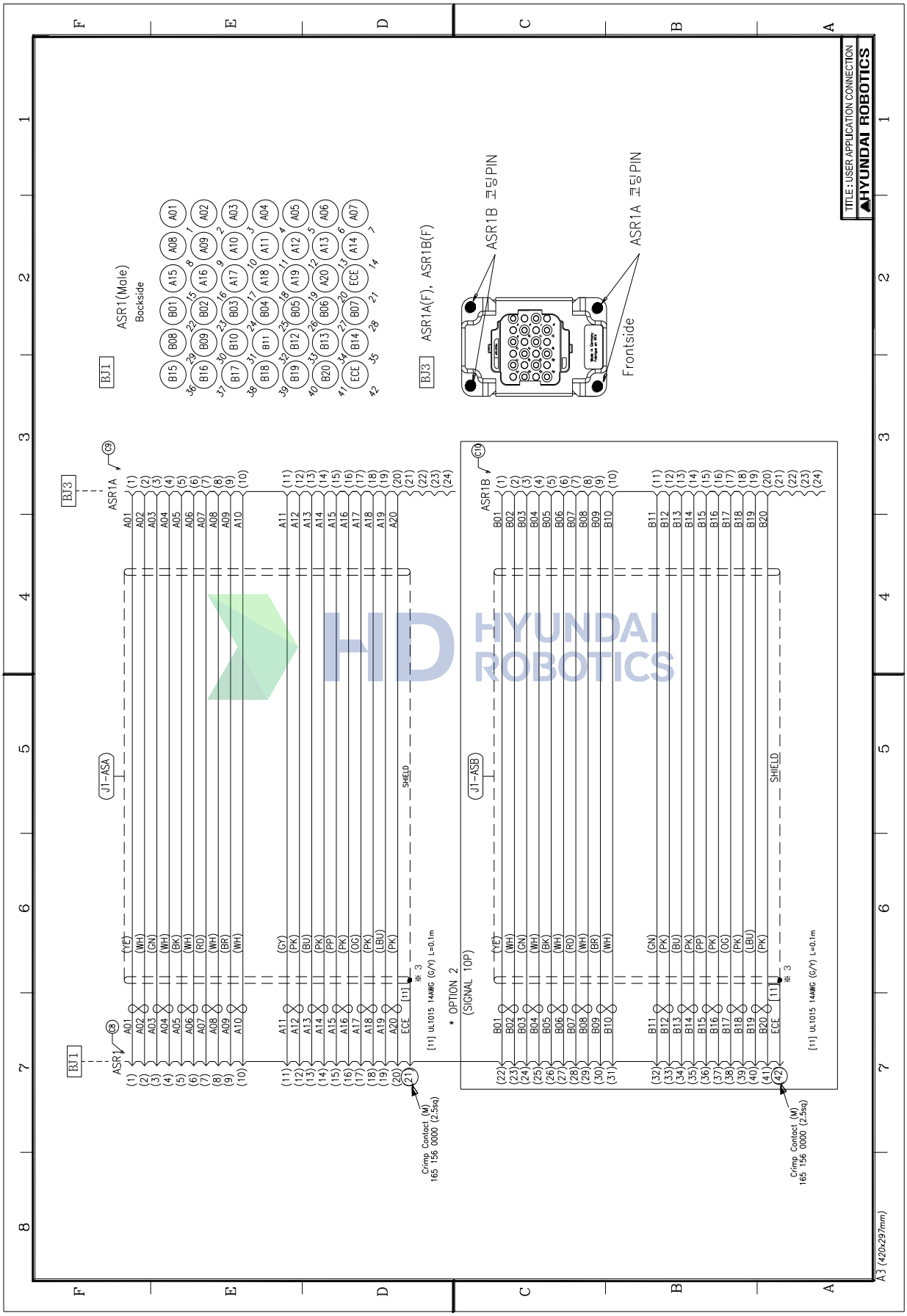

TITLE : MOTOR POWER CABLE CONNECTION FOR S,H,V AXIS
HYUNDAI ROBOTICS
CNMB1 (MS3108B24-10S)
CNMB2 (MS3108B24-10S)
CNMB3 (MS3108B24-10S)
CMR1(M)
Backside
BJ1
BJ2
BJ3
CNMB1
CNMB2
CNMB3
S-AXIS MOTOR
H-AXIS MOTOR
V-AXIS MOTOR
TSM3611 5.9Kw
J1-MB1
J1-MB2
J1-MB3
{TERMINAL 2-4R}
A3 (420x297mm)


TITLE : MOTOR POWER CABLE CONNECTION FOR R2,B,R1 AXIS
HYUNDAI ROBOTICS
CMR2(M)
Backside
R2-AXIS MOTOR
B-AXIS MOTOR
R1-AXIS MOTOR
TSM3508 3.7Kw
RECEPTACLE VLR-06V
PLUG VLP-06V
CMR2
J1-B456
J1-M456
BJ1
BJ2
BJ3
{TERMINAL 2-4R}
A3 (420x297mm)


CER1(Male)
Backside
S-AXIS ENCODER
H-AXIS ENCODER
CNLS1A
CNLS1
CNLS2A
CNLS2
CNLS3
S-AXIS LS (P1a)
H-AXIS LS (P1b)
V-AXIS LS (P1c)
* UL-OPTION
LIMIT SWITCH TYPE
USE
TYPE
CABLE 형상
S-AXIS (P1a)
D4N-5822
H-AXIS (P1b)
D4N-5832
V-AXIS (P1c)
D4N-5832
RECEPTACLE SMR-04V-B
PLUG SMP-04V-BC
RECEPTACLE SMR-02V-B
PLUG SMP-02V-BC
RECEPTACLE SMR-07V-B
PLUG SMP-07V-BC
TITLE : MOTOR ENCODER CABLE CONNECTION FOR S,H AXIS
HYUNDAI ROBOTICS
A3 (420x297mm)


TITLE : MOTOR ENCODER CABLE CONNECTION FOR V,R2,B,R1 AXIS
HYUNDAI ROBOTICS
CER1(Male)
Backside
AER1A(F)
* OPTION 1
(ROBOT SERVO GUN ENCORDER)
V-AXIS ENCODER
R2-AXIS ENCODER
B-AXIS ENCODER
R1-AXIS ENCODER
BJ1
BJ3
J1-E34567
CER1
CNE3
CNE4
CNE5
CNE6
AER1A
SHIELD
A3 (420x297mm)




TITLE : USER APPLICATION CONNECTION
HYUNDAI ROBOTICS
ASR1(Male)
Backside
BJ1
ASR1A(F), ASR1B(F)
BJ3
ASR1B 코딩PIN
ASR1A 코딩PIN
Frontside
J1-ASA
J1-ASB
ASR1
ASR1A
ASR1B
* OPTION 2
(SIGNAL 10P)
SHIELD
Crimp Contact (M)
165 156 0000 (2.5sq)
[11] UL1015 14AWG (G/Y) L=0.1m
A3 (420x297mm)

GRC: 477, Bundangsuseo-ro, Bundang-gu, Seongnam-si, Gyeonggi-do

Daegu: 50 Technosunhwan-ro 3-gil, Yuga-eup, Dalseong-gun, Daegu-si

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