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QUALIFIED INSTALLATION PERSONNEL AND
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LOCAL CODES



Hyundai Robot

HX400L230602MMEN4



Manipulator Maintenance Manual

HX400L





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Safety



1. Safety

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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.

The dangerous zone of robot system, that is the working range in which the robot, tool, and peripheral equipment are operated, must be safeguarded to prevent workers or objects from entering the zone. If a person or object should nevertheless enter the dangerous zone, make sure that the robot system is immediately shut down by emergency stop system. The operators of robot system have a responsibility to take all necessary steps to make correct installation, examination and operation of the relevant safety devices.

Enable application and disable environment of robots are as follows.

Application

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
- MIG/MAG welding
- 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 potentially hazardous situation which, if not avoided, could result in death or serious injury to personnel and damage to equipment. The special attention must be paid to the operation and handling.
Mandatory		Indicate the compulsory measures that should be performed.
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

▶▶ Definition of Safety Functions - IEC 204-1,10,7

There is one emergency stop button on the controller and teach pendant respectively. If necessary, additional emergency buttons should be able to connect to the robot's safety chain circuit. The emergency stop function, which overrides all other robot controls, stops all moving parts by disconnecting power supply, and removes drive power to prevent the use of other dangerous functions controlled by the robot.

▶▶ Safety Stop Function - EN ISO 10218-1:2006

When a safety stop circuit is provided, each robot must be delivered with the necessary connections for the safeguards and interlocks associated with this circuit. 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 speed of robot is strictly limited to 250 mm per second as maximum. 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 must be operated either manually or automatically. In a manual mode, the robot must 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.

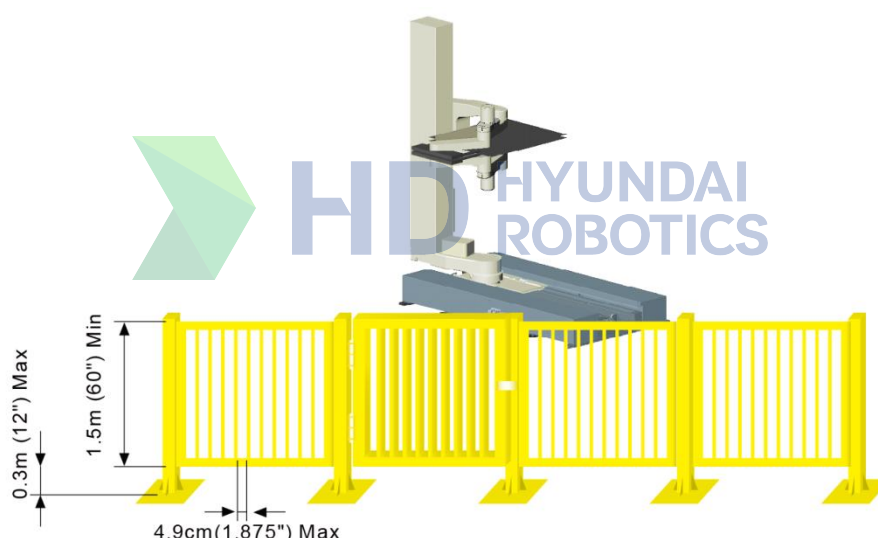


Figure 1.1 Recommended size for safety net and entrance gate (slot type entrance gate)

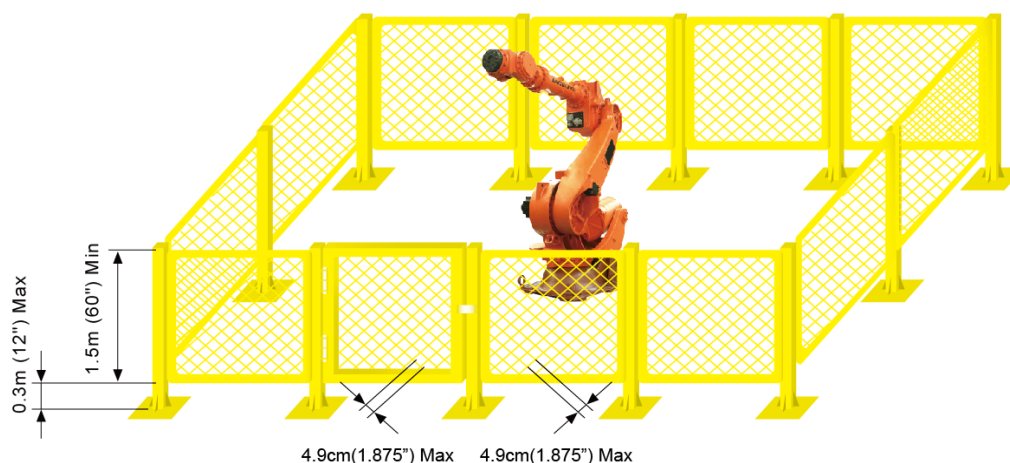


Figure 1.2 Recommended size for safety net and entrance gate (square type entrance gate)

- (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. And, please make wiring with interlock so that robot would be operation ready OFF and motor OFF in the status that safety plug is pulled out or safety net is open.
- (4) When intending to operate the robot with the safety plug pulled out, wire the robot as a low-speed play mode.
- (5) For immediate emergency stop, install emergency stop button within operator's easily accessible distance.
- (6) In case of no safety net, please install photoelectric switch, mat switch and so on instead of safety plug in all range of robot operation, and make robot to stop automatically when man goes into.
- (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 the stand stops in an emergency wherever the robot is handled.
- (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. The accident by falling down of work or wire cut can happen.
- (6) Place the controller, interlock panel, and handling stand within the sight of robotic performance. It may cause a serious accident to operate the robot while the operator is working, or the robot is malfunctioning in an invisible sight.
- (7) Restrict the robot's working envelope by using soft limits and mechanical stopper if the necessary working envelope is narrower than the holding workable envelope. It is possible to stop the robot in advance when it moves beyond its normal working envelope due to an abnormal condition. (Refer to the 『Robot Manipulator Maintenance Manual』.)
- (8) During weld, spatter can fall down to workers or the workers can be injured by burning, or fire can 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 must be noticeable even in the far distance. In the case of automatic start-up, warning with a buzzer or warning lamp is also enable.
- (10) Make sure that there is no projecting part in the robot's peripheral equipment. Cover it, if necessary. It usually may cause an accident if the operator comes in touch with it. And it may lead a serious accident if the operator is astonished at the sudden movement of robot, and conducts it.

- (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.



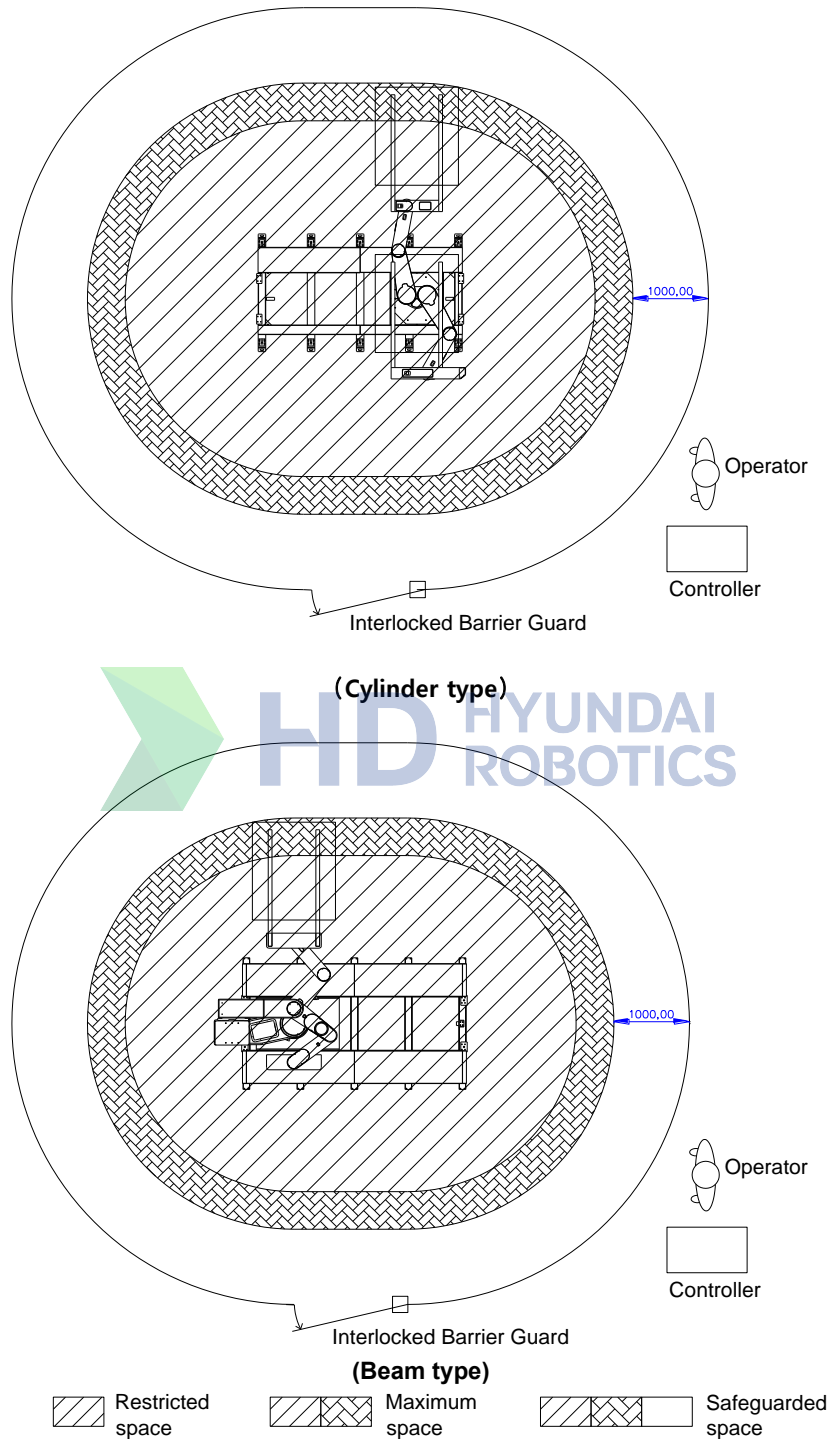


Figure 1.3 Arrangement of LCD robot peripheral devices and workers

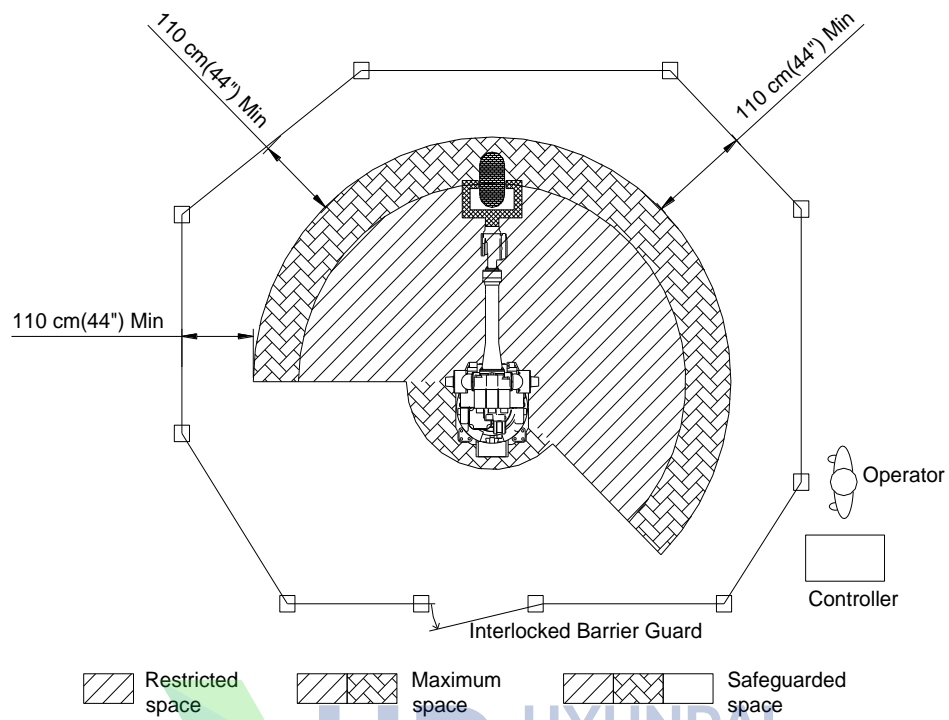


Figure 1.4 Arrangement of general robot peripheral devices and workers

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°C.
- (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 or 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 on operation of 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 entering into safeguard 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, take the teach pendant with you so that other people may not operate the robot. Make sure to post up the control panel a sign indicating the state of robot handling.

Read carefully and be aware of the follows when entering the 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 observe following managing articles after the repair and check.

- (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

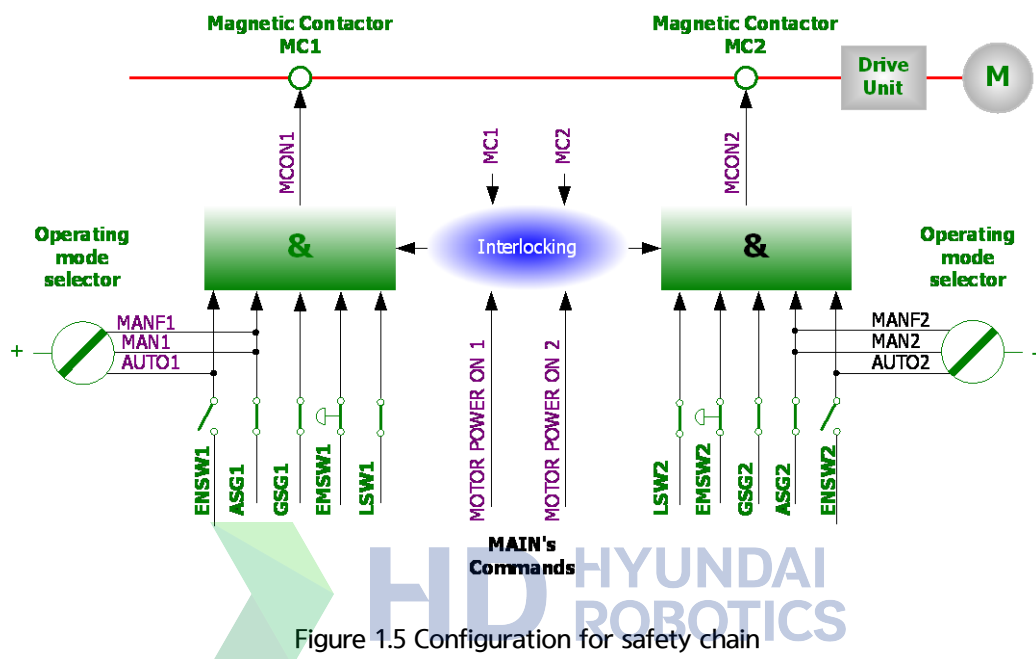


Figure 1.5 Configuration for safety chain

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 status in the menu: “『[F2]: System』 → 『3. Robot parameter』 → 『2. Axis constant』 / 『3. Soft limit』 / 『4. Encoder offset』 ”.)



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.

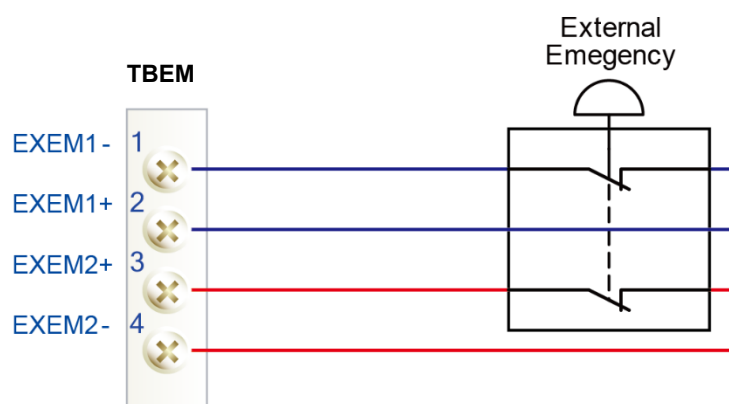


Figure 1.6 Connection with external emergency halt switch through system board terminal block TBEM

1.10.1. 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.

1.10.2. 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.

1.10.3. 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.

1.10.4. 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. Specifications

HX400L

2.1. Robot Machinery Part

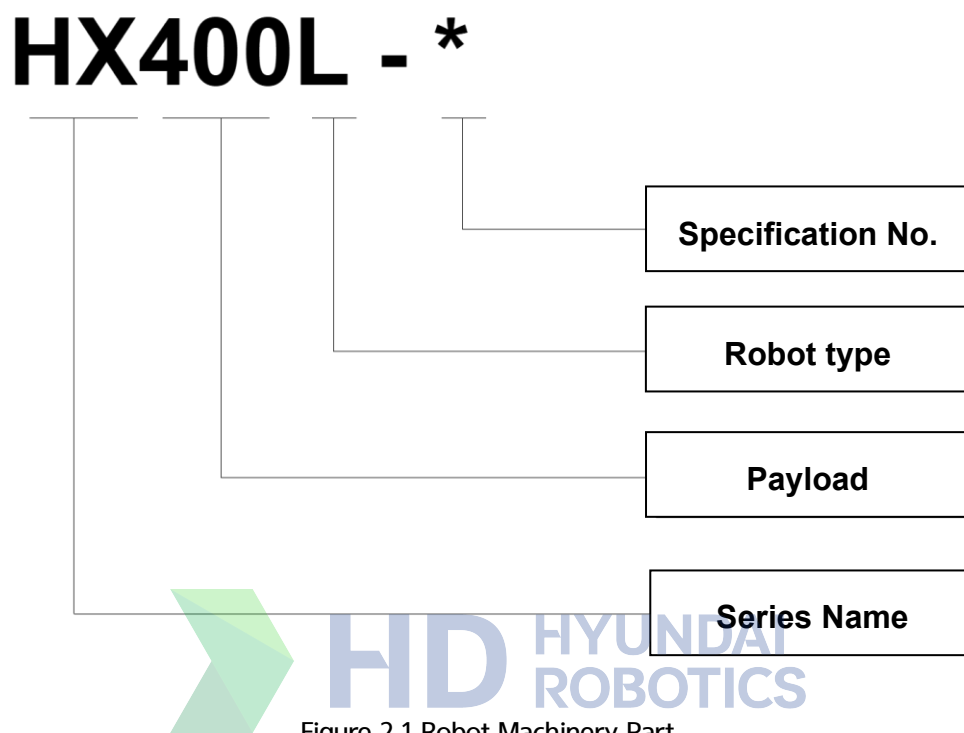


Figure 2.1 Robot Machinery Part

2.2. Location of Robot Identification Plate

The model name, serial number, and manufacturing date of robot are written down in the name plate. The name plate is located on the right side of the base body seen from the front of the robot, as shown in the following figure:

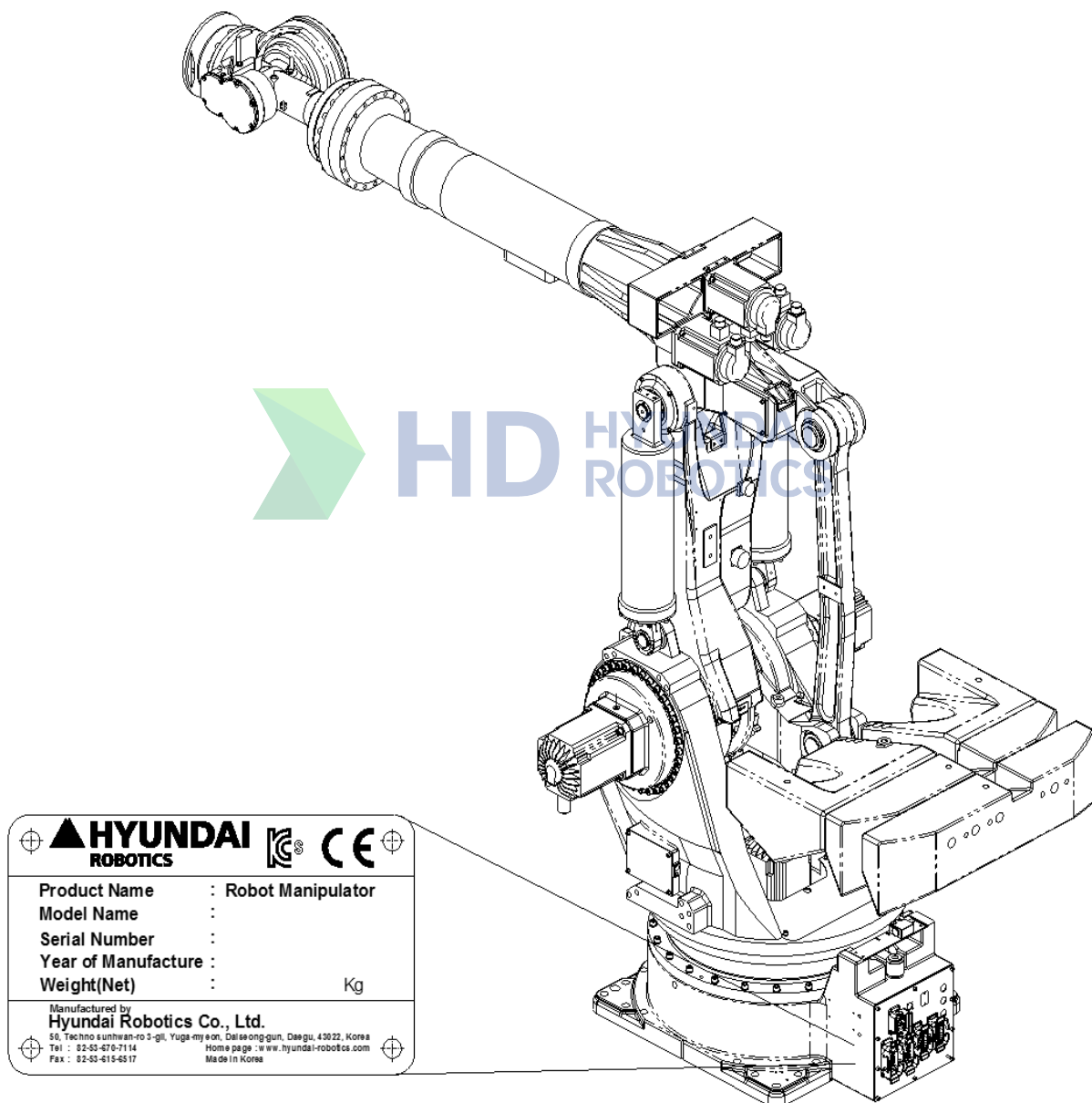


Figure 2.2 The location of identification plate

2.3. Basic Specifications

Table 2-1 Basic Specifications for Models

Item				Specification
Model				HX400L
Construction				Articulated
Degree of freedom				6
Drive system				AC servo system
Max. Working envelope	Arm	S	Swivel	$\pm 3.14 \text{ rad } (\pm 180^\circ)$
		H	For/Backward	$+2.87 \sim +0.26 \text{ rad } (+165^\circ \sim +15^\circ)$
		V	Up/ downward	$+1.04 \sim -1.22 \text{ rad } (+60^\circ \sim -70^\circ)$
	Wrist	R2	Rotation 2	$\pm 6.28 \text{ rad } (\pm 360^\circ)$
		B	Bending	$\pm 2.09 \text{ rad } (\pm 120^\circ)$
		R1	Rotation 1	$\pm 6.28 \text{ rad } (\pm 360^\circ)$
Max. Speed	Arm	S	Swivel	$1.48 \text{ rad/s } (85^\circ/\text{s})$
		H	For/Backward	$1.48 \text{ rad/s } (85^\circ/\text{s})$
		V	Up/ downward	$1.48 \text{ rad/s } (85^\circ/\text{s})$
	Wrist	R2	Rotation 2	$1.74 \text{ rad/s } (100^\circ/\text{s})$
		B	Bending	$1.74 \text{ rad/s } (100^\circ/\text{s})$
		R1	Rotation 1	$2.79 \text{ rad/s } (160^\circ/\text{s})$
Load Capacity				400 kg
Wrist Torque		R2	Rotation 2	1,960 N.m(200 kgf.m)
		B	Bending	1,960 N.m(200 kgf.m)
		R1	Rotation 1	823 N.m(84 kgf.m)
Accuracy of position repeatability				$\pm 0.3 \text{ mm}$

2. Specifications

Item	Specification
Model	HX400L
Ambient Temperature	0 ~ 45 °C (273 ~ 318 K)
Relative humidity	20 ~ 85 %RH
Robot's Weight	2,950 kg
Working envelope section area	6.18 m ²



2.4. Robot Dimension and Working Envelope

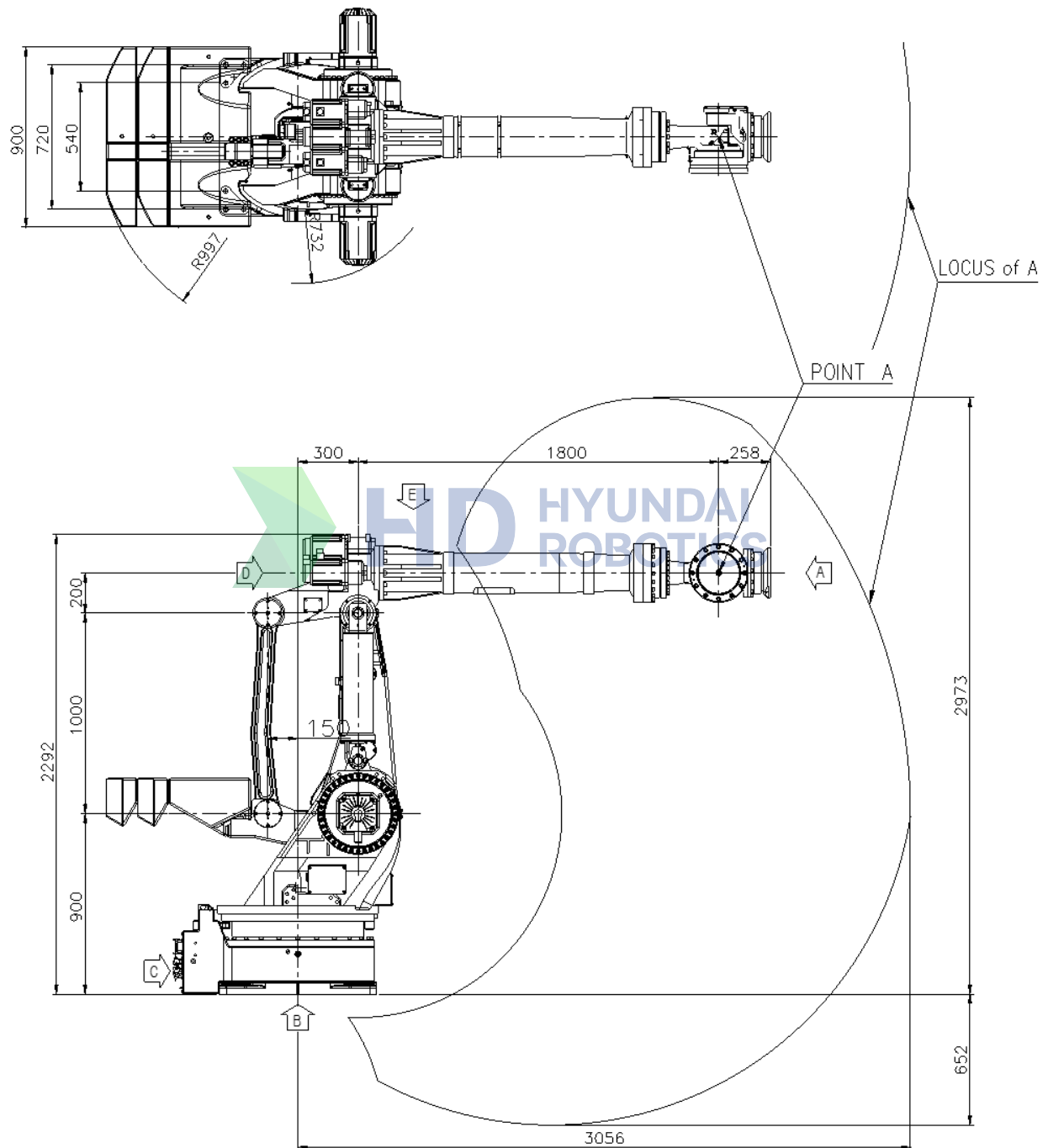


Figure 2.3 Robot Dimension and Working Envelope

2.5. Axis Identification

Table 2-2 Axis Motion

Axis Name	Operation	Teach Pendant Button	
S	Arm Swivel	LFT(S+)	RHT(S-)
H	Arm Forward and Backward	BWD(H+)	FWD(H-)
V	Arm Upward and Downward	UP(V+)	DOWN(V-)
R2	Wrist Rotation 2	Rx+(R2+)	Rx-(R2-)
B	Wrist Bend	Ry+(B+)	Ry-(B-)
R1	Wrist Rotation 1	Rz+(R1+)	Rz-(R1-)

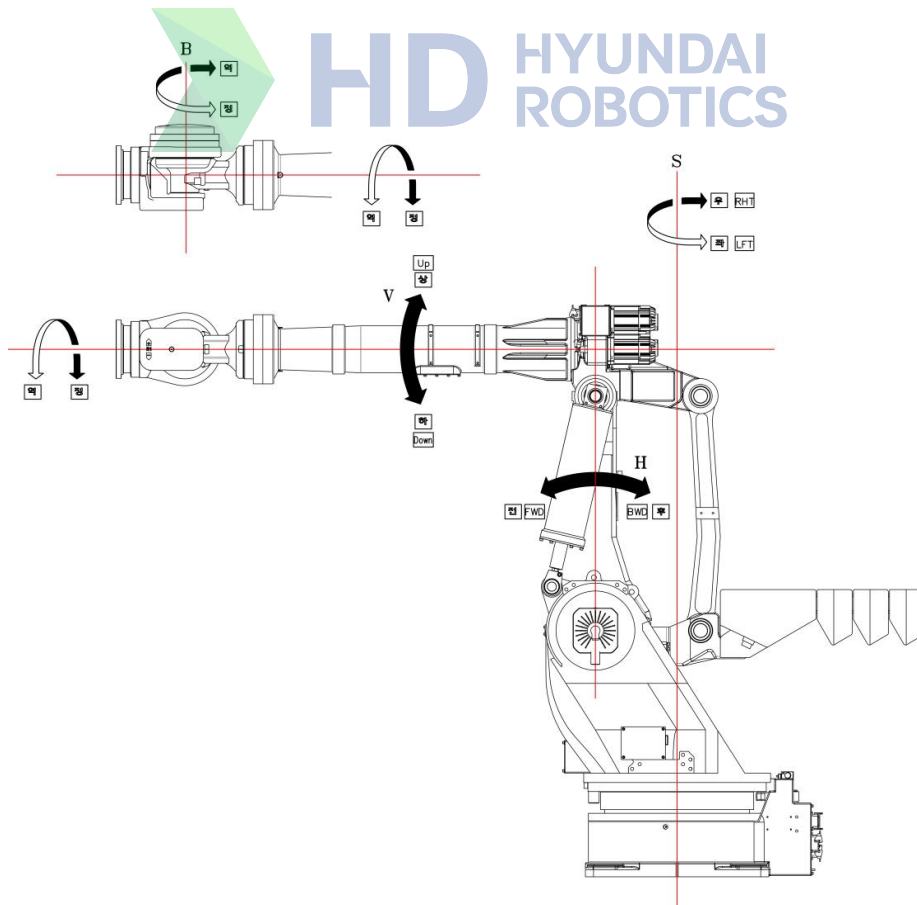


Figure 2.4 Robot Dimension and Axis

2.6. Details of Wrist Axis Attachment Surface

When attaching the operating tool to the mechanical interface of robot's wrist flange, fasten it with a bolt at P.C.D. 200.

(6-M12 Bolt, $\varnothing 12$ H7 Pin Hole)

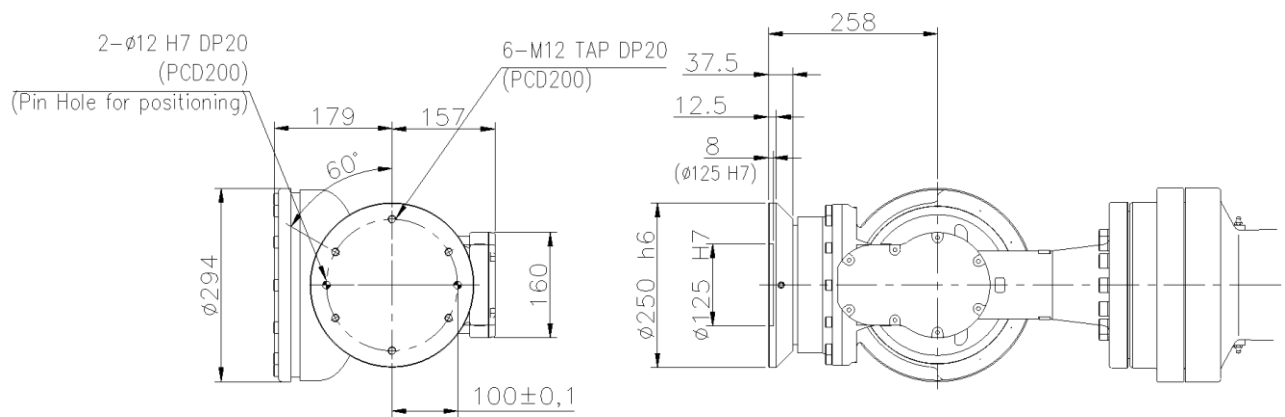


Figure 2.5 Details of Wrist Axis Attachment Surface

2.7. Detailed drawing of the part to which the upper arm is attached

It has a machined tap for attaching a peripheral device to the upper arm of the robot.
Within the area marked with ■, peripheral devices (valves, etc.) shall be attached.

[Attention]

Attach a peripheral device to only one of the two points: the top of the arm pipe or the top of the V-axis. When attaching, be sure to the center position of gravity should be located within the range marked as ■.

- Maximum load of the top of the V-axis (arm frame) : 80kg
- Maximum load of the top of the arm pipe : 80kg

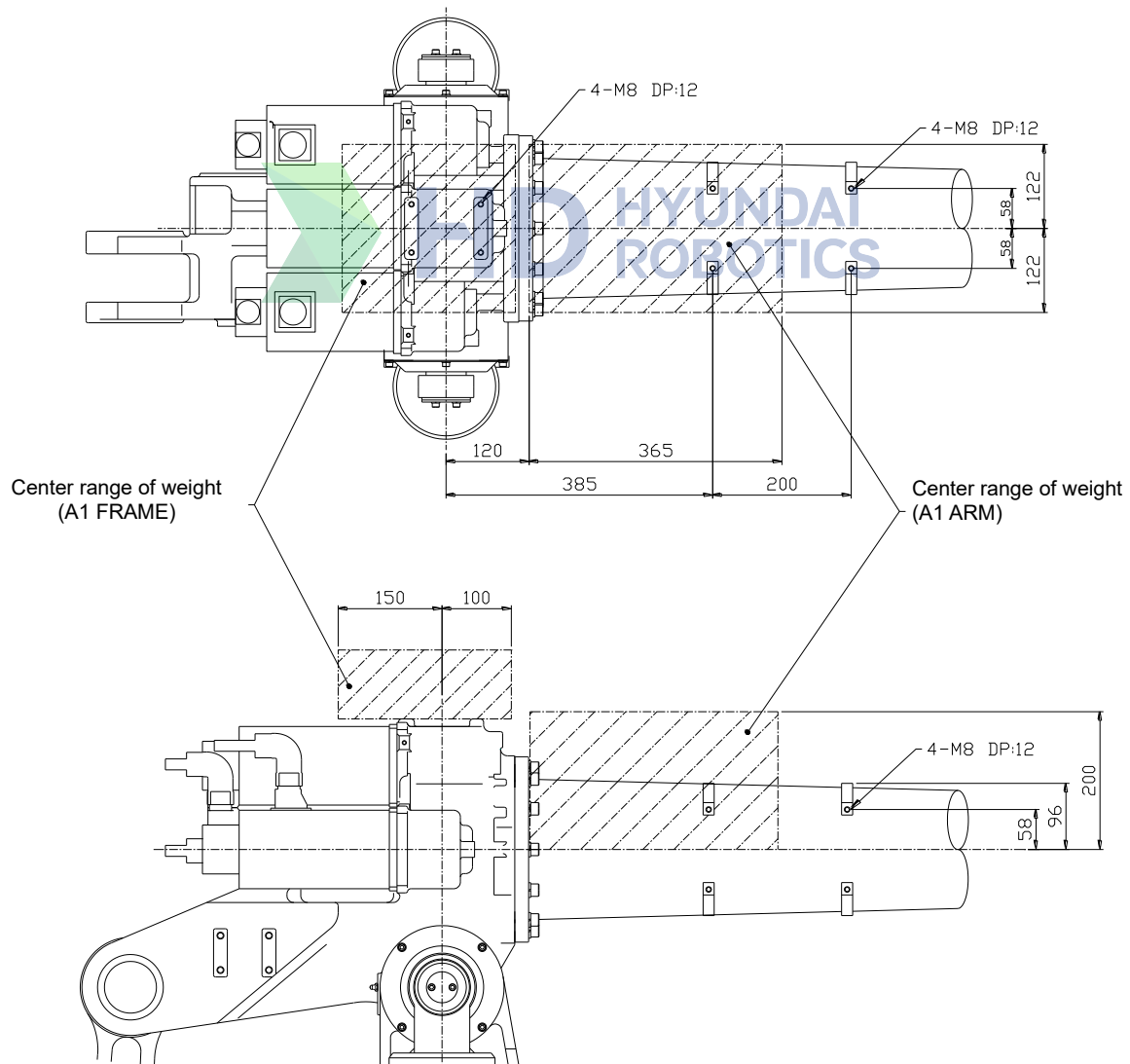


Figure 2.6 Detailed drawing of the part to which the upper arm is attached



2.8. Application Wiring and Inspection Wiring Diagram

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

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

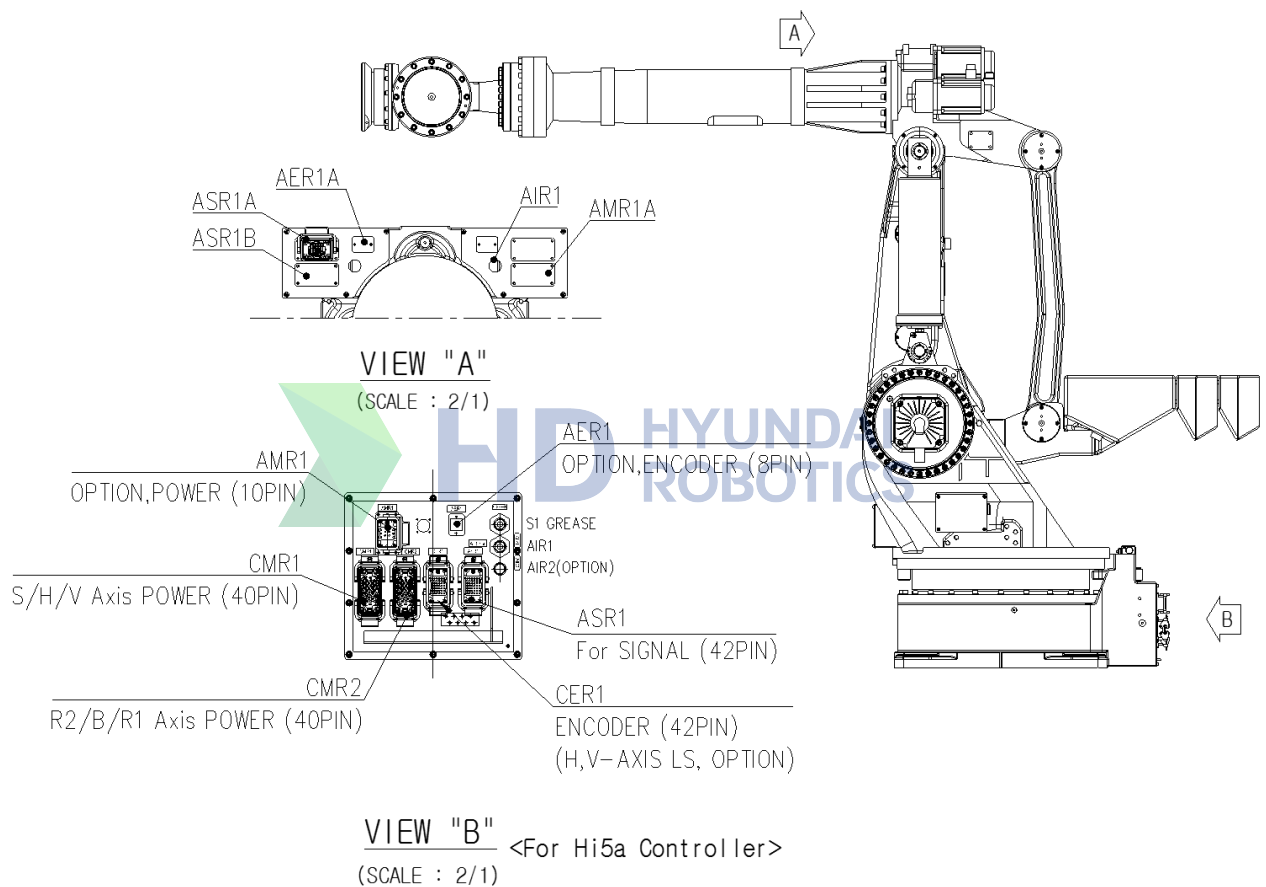


Figure 2.7 Application Wiring and Inspection Wiring Diagram

2.8.1. Detailed drawings of wiring connector for application

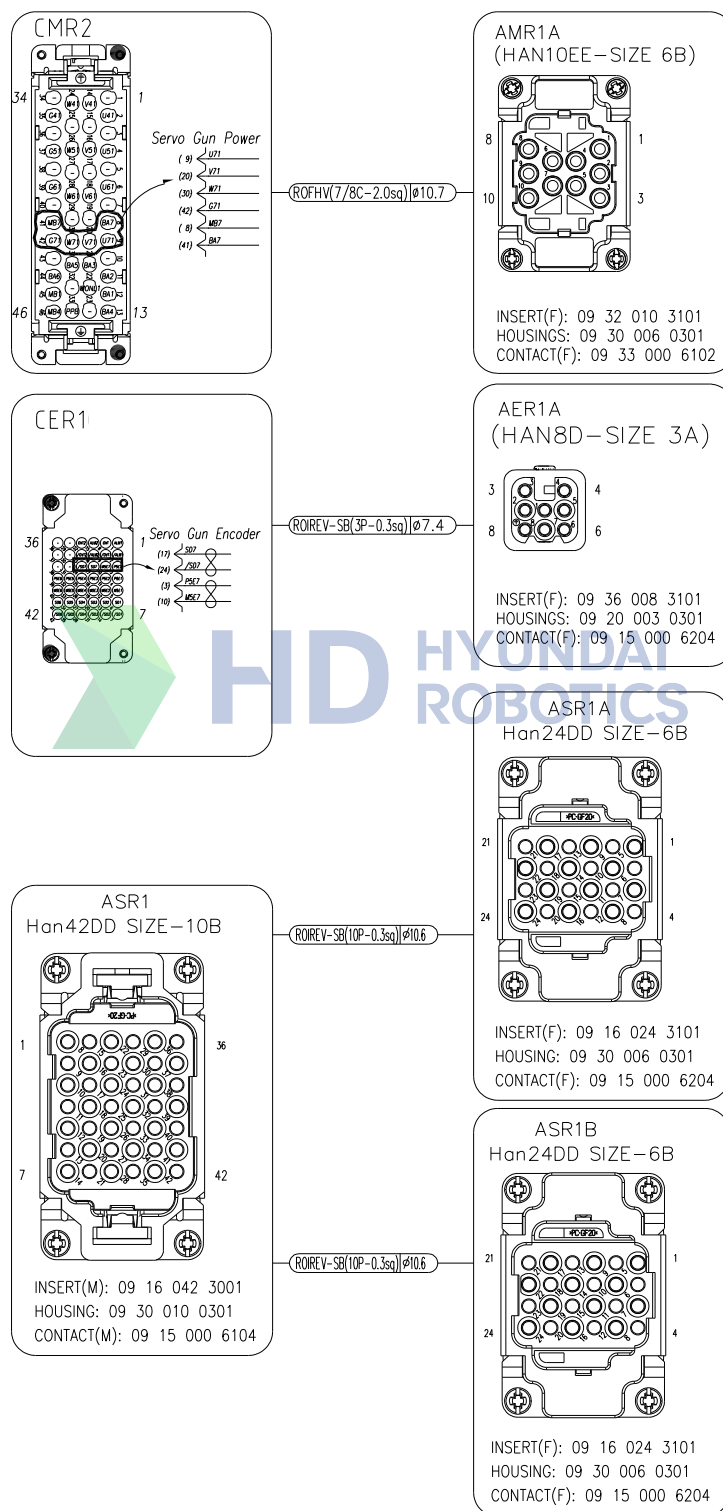


Figure 2.8 Detailed drawings of application connector

2.9. Restricting the Working Envelope

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

Limiting the motion range is useful when:

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

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

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



[Warning]

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

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

2.9.1. Axis 1(Axis S)

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





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3

Instructions



3. Instructions

HX400L

3.1. Robot Component Name

The name of each component is described in [Figure 3.1] and [Table 3-1].

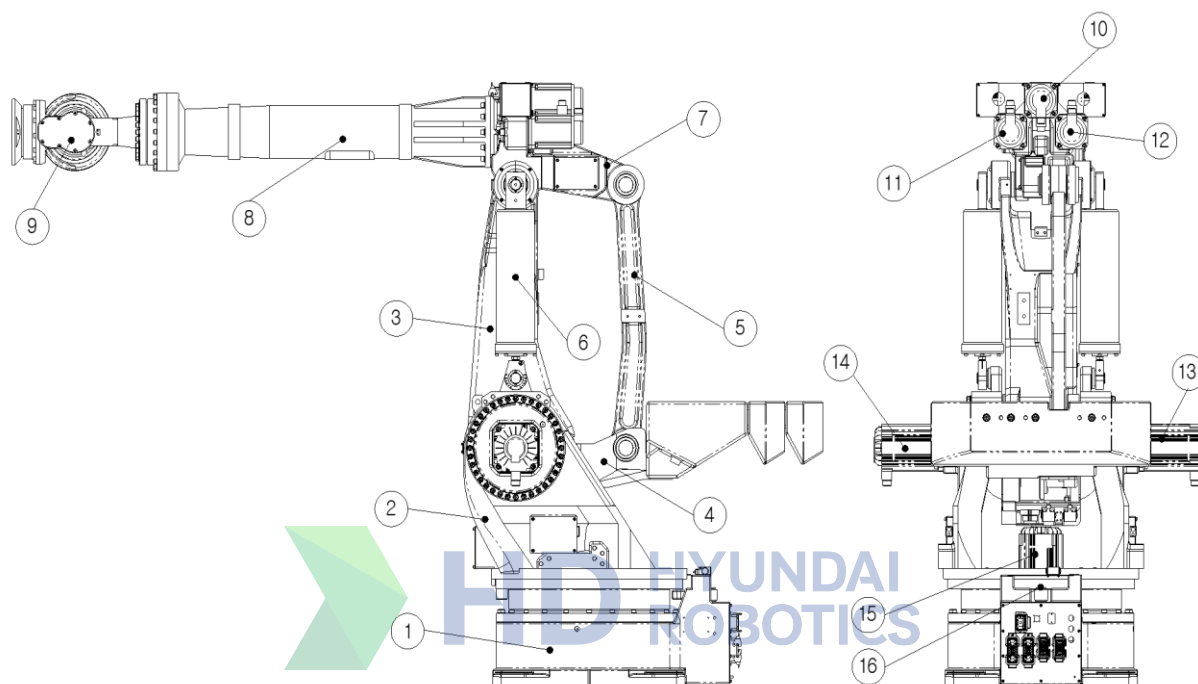


Figure 3.1 Name of Robot Components

Table 3-1 Name of Robot Components

No.	Name of each part	No.	Name of each part
1	Base Body	9	Wrist
2	Lower Frame	10	R2 Axis motor
3	Upper Frame	11	B Axis motor
4	Hinge	12	R1 Axis motor
5	Link	13	V Axis motor
6	Balance Spring	14	H Axis motor
7	Arm Frame	15	S Axis motor
8	Arm Pipe	16	S Axis limit switch

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.

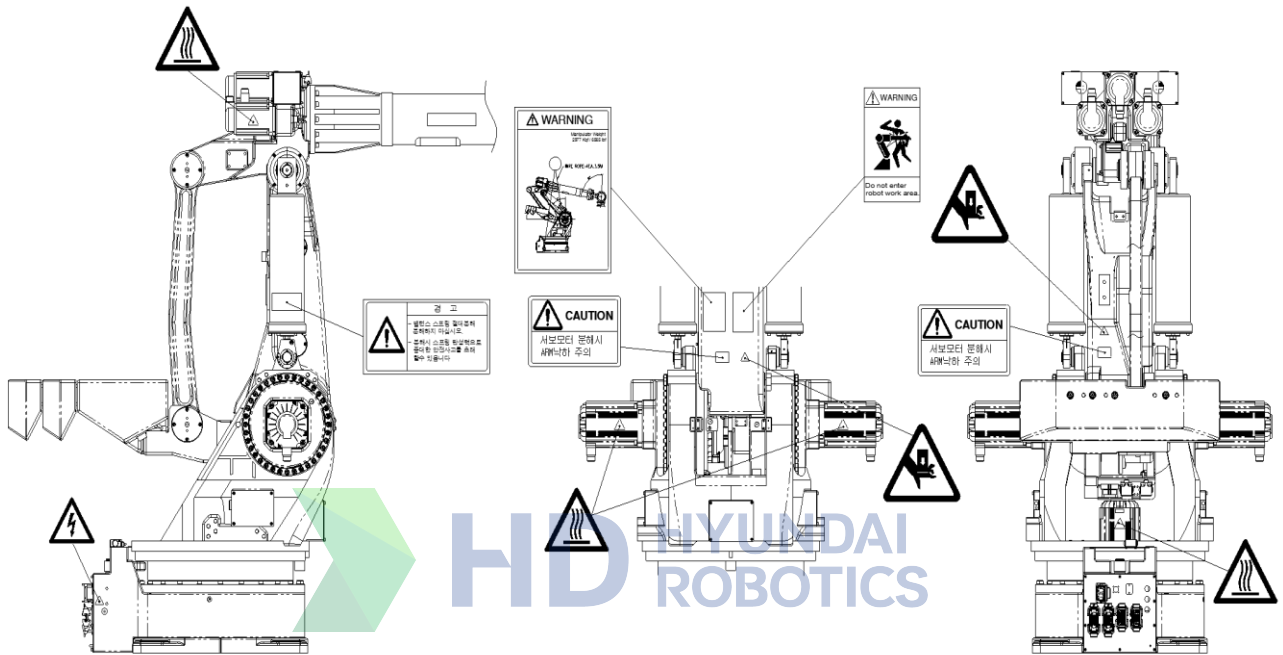


Figure 3.2 Location of Safety Nameplate

3.3. How to Transport

3.3.1. Using Crane

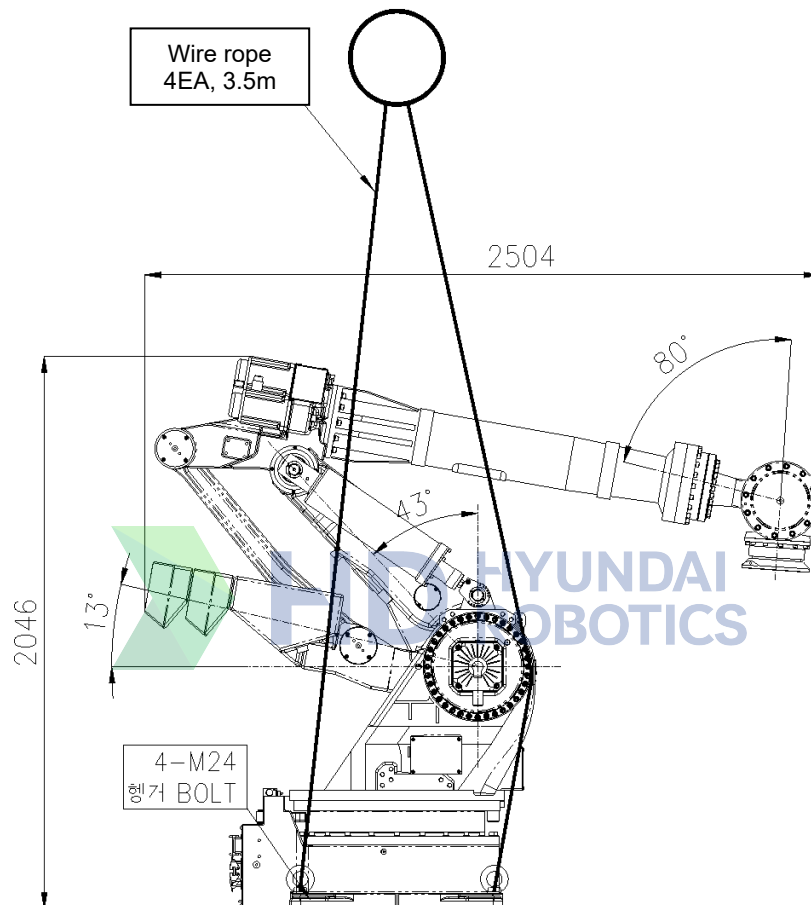


Figure 3.3 How to Transport: Using crane

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



- Never walk under the robot.
- Pose the robot as shown in the Figure.
- Fasten 4 eye bolts at the 4 points of the base body.
- Connect a wire rope to the eye bolts.
- Use 4 piece of protective hose(four parts/ 50cm) to prevent damage.
- Keep the safety regulations during Lifting process.
- Weight of manipulator : 2,950kg
- Minimum crane capacity: 3 tons



※ Insert a protective hose to prevent damage of painting at the parts contacted with robot body. Refer to Figures for the proper location of protective hose.

3.3.2. Forklift use

A forklift can be used to carry the main body of the robot. The bracket for the forklift transporting, as an option, is provided.

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

- With reference to the pictures provided, use the standard position of each model.
- Before forking, fasten each bracket(2) for forklift to the left and right side of A2 Frame with 4 pieces of M12 bolts and flat washer.
- Carry at a slow speed.
- Follow all safety regulations.



Cautions

- Do not lean against the robot while carrying it.
- Make sure the robot does not collide with the floor while loading and unloading.
- Pay attention to the relevant safety rules while using the forklift truck.

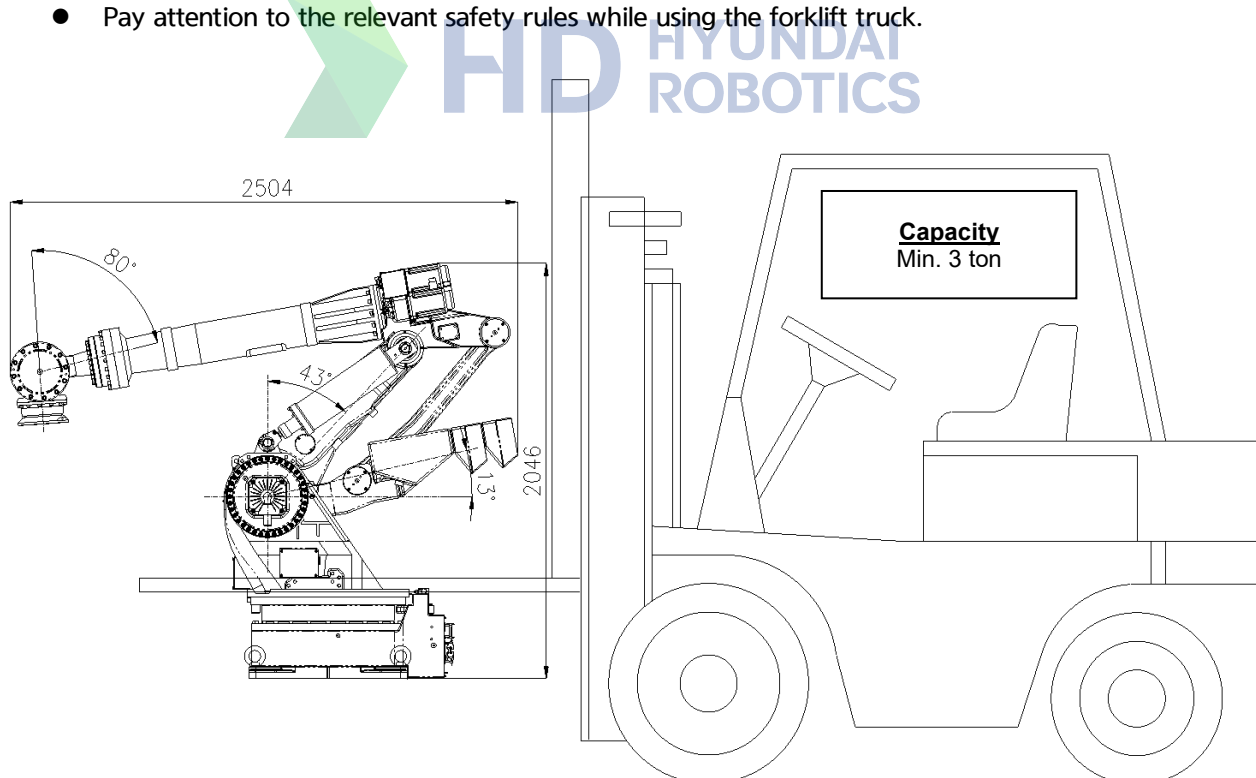


Figure 3.4 How to Transport : Using forklift

3.4. How to Install



NOTE:

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



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.

3.4.1. Operating Conditions

- (1) Ambient temperature should range from 0°C to 45°C.
- (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°C ~ and 40°C.

3.4.2. Installation the Robot Manipulator

The main body of the robot must be fixated firmly with 8 M20 bolts. All 8 bolts must be used.

- Bolt : M20(12.9) SOCKET HEAD BOLT
- Washer : OD = 37mm, ID = 22mm, T = 3.2mm
- Assembly torque : 380Nm

The base floor to install the robot should be constructed with concrete with a thickness of 200mm or more so that the hardness minimizes dynamic effect to the robot. Repair bumps and cracks on the concrete surface of the floor during installation, and fix the mounting place with M20 Chemical Anchor. And if the thickness of the concrete floor is less than 200mm, it requires an independent base construction that must be reviewed beforehand.

※ Allowable load of bolts

The repeated tensile load per bolt : Approximately 8,820 N (900 Kgf)

3.4.3. Accuracy of Installation Surface

The degree of flatness for the four attachment plate surfaces should satisfy the specification. Use a shim, if necessary. The rest of the surface must be flat within $\pm 2\text{mm}$.

■ Cautions

- (1) The flatness of mounting plate must be within 1.0 mm.
- (2) Make four plane figures of a sealed plate of 1.0 mm ($\pm 0.5\text{ mm}$) or less.

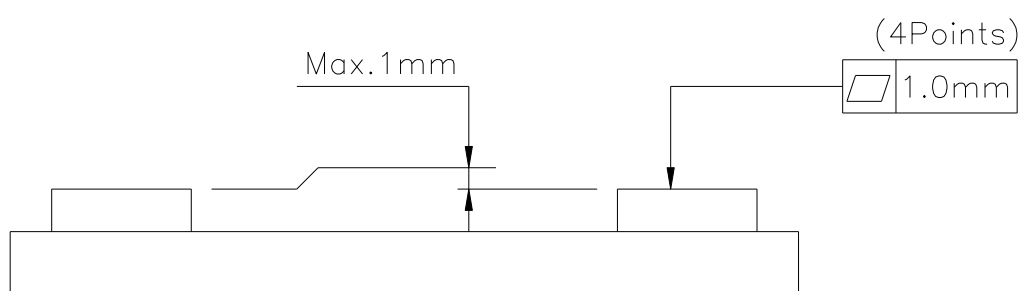


Figure 3.5 Accuracy of Installation surface

3-8

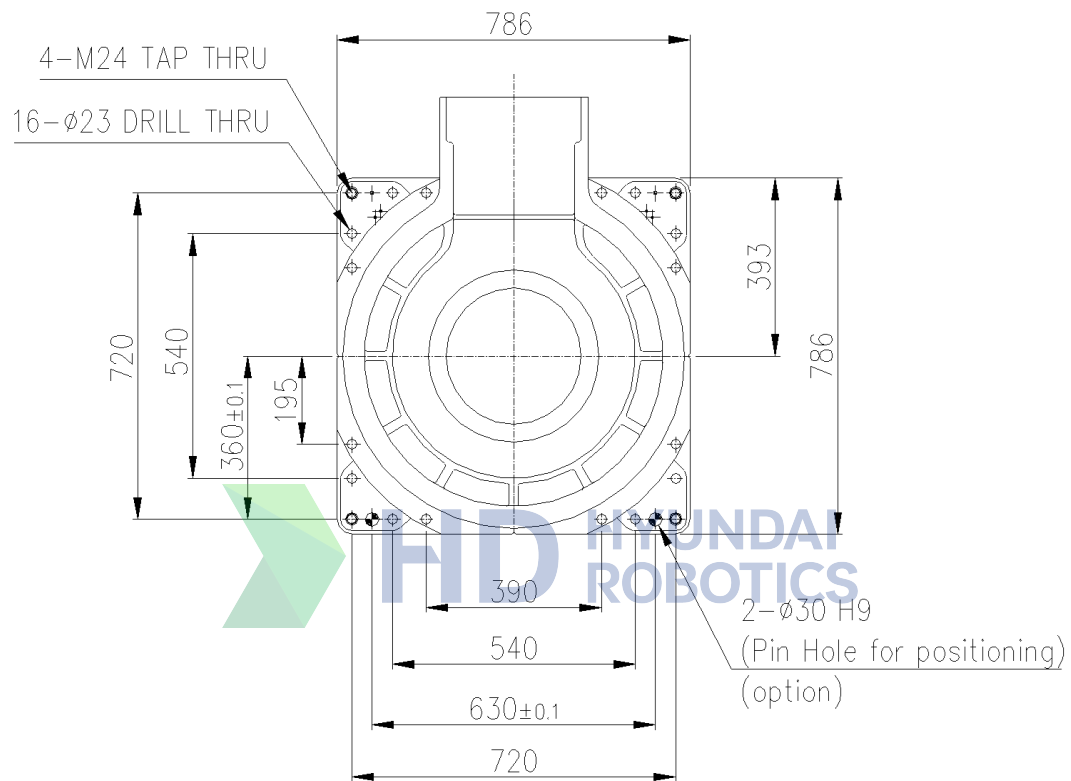


Figure 3.6 Dimension of Robot Installation

3.5. Allowable Load of Wrist Axis

3.5.1. Permitted load torque estimation

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

■ Step 1

Calculate the location of the weight center from the B axis rotation center (L_X , L_Y , L_Z)

L_X : Location of weight center in X axis

L_Y : Location of weight center in Y axis

L_Z : Location of weight center in Z axis

■ Step 2

Distance calculation from the axis B and R1 to the center of gravity

$$L_B = \sqrt{L_X^2 + L_Z^2}, \quad L_{R1} = \sqrt{L_Y^2 + L_Z^2}$$

L_B : Length from B axis rotation center to weight center

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

■ Step 3

Calculate the load torque from the calculated distance.

$$T_B = MgL_B \quad T_{R1} = MgL_{R1}$$

T_B : Load torque in the rotational center of axis B

T_{R1} : Load torque in the rotational center of axis R1

M : Mass of load

g : Acceleration of gravity

■ Step 4

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

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

Allowable Load Torque :

Table 3-2 Allowable Load Torque

Robot Model	Allowable Load Torque		
	R2 Axis Rotation	B Axis Rotation	R1 Axis Rotation
HX400L	1,960N·m(200kgf·m) or less	1,960 N·m(200kgf·m) or less	823 N·m(84 kgf·m) or less

3.5.2. Permitted inertia moment estimation

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

- Step 1
Calculate the inertia moment value of the load at each wrist axis center (J_{a4} , J_{a5} , J_{a6})
 J_{a4} - Inertia moment from R2 axis rotation center
 J_{a5} - Inertia moment from B axis rotation center
 J_{a6} - Inertia moment from R1 axis rotation center
- Step 2
Check whether the inertia moment value is within the limit based on the allowed inertia moment table

**Allowable Moment of Inertia :**

Table 3-3 Allowable Moment of Inertia

Robot Model	Allowable Moment of Inertia		
	R2 Axis Rotation	B Axis Rotation	R1 Axis Rotation
HX400L	120kg·m ² (12.2kgf·m·s ²)	120kg·m ² (12.2 kgf·m·s ²)	50 kg·m ² (5.1 kgf·m·s ²)

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

(1) Case #1 Simple 2-D model

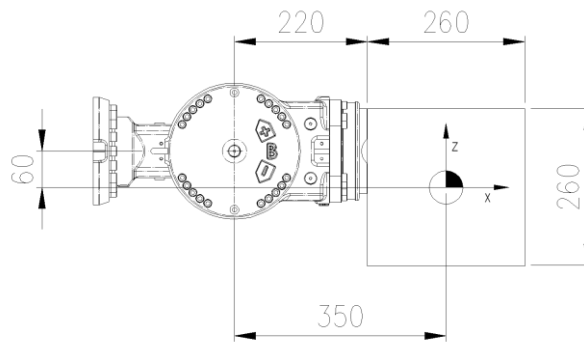


Figure 3.7 2-D load model

M – Load weight

J_{xx} – Inertia moment in X direction from weight center of load

J_{yy} – Inertia moment in Y direction from weight center of load

J_{zz} – Inertia moment in Z direction from weight center of load

J_{a4} – Inertia moment from R2 axis rotation center

J_{a5} – Inertia moment from B axis rotation center

J_{a6} – Inertia moment from R1 axis rotation center

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

① Weight limitation

Load weight : $138.15 \leq 180 \text{ kg}$

② Permitted torque limit

Location of B axis weight center $L_x = 350\text{mm}$, $L_y = 0\text{mm}$, $L_z = -60\text{mm}$

The distance from the axis B and R1 to the center of gravity can be calculated as follows

B axis based length $L_B = \sqrt{0.35^2 + 0.06^2} = 0.355 \text{ m}$

R1 axis based length $L_{R1} = 0.06 \text{ m}$

Load torque of axis B $T_B = MgL_B = 49.04 \text{ kgfm} \leq 110 \text{ kgfm}$

Load torque of axis R1 $T_{R1} = MgL_{R1} = 8.29 \text{ kgfm} \leq 58 \text{ kgfm}$

③ Permitted inertia moment limit

Inertia moment of load from the weight center $J_{xx} = 1.56\text{kgm}^2$, $J_{yy} = 1.56 \text{ kgm}^2$, $J_{zz} = 1.56 \text{ kgm}^2$

B axis inertia moment (Ja5)

$$J_{a5} = ML_B^2 + J_{yy} = 138.15 \times 0.355^2 + 1.56 = 18.97 \leq 106 \text{ kgm}^2$$

R1 axis inertia moment (Ja6)

$$J_{a6} = ML_{R1}^2 + J_{xx} = 138.15 \times 0.06^2 + 1.56 = 2.06 \leq 56 \text{ kgm}^2$$

④ Conclusion

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

(2) Case #2 Complicated 3-D model

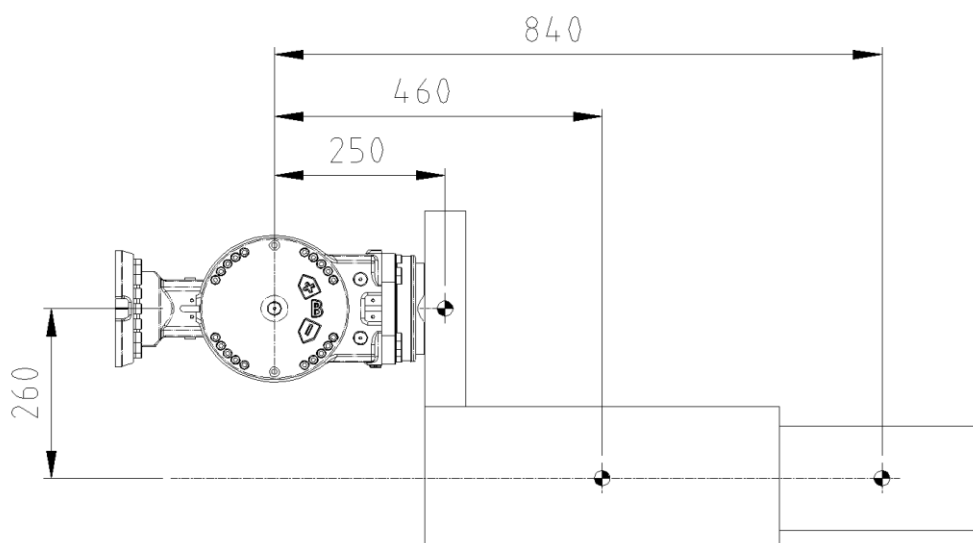


Figure 3.8 3-D load model 2-D shape

Aluminum block shape combination

($\sigma = 0.0027 \text{ g/mm}^3$: 176.3 kg)

m1 (60 × 300 × 300) 14.6kg

m2 (480 × 440 × 220) 125.4kg

m3 (280 × 300 × 160) 36.3kg

m_i – Weight of ‘i’ block load

L_{xi} – Weight center location in X axis direction of ‘i’ block

L_{yi} – Weight center location in Y axis direction of ‘i’ block

L_{zi} – Weight center location in Z axis direction of ‘i’ block

① Weight limitation

Load weight : $176.3 \leq 180 \text{ kg}$

② Permitted torque limit

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

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

$$L_y = 0 \text{ mm (Symmetric to Y axis)}$$

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

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

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

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

$$\text{Load torque of axis B } T_B = MgL_B = 101.02 \text{ kgfm} \leq 110 \text{ kgfm}$$

$$\text{Load torque of axis R1 } T_{R1} = MgL_{R1} = 41.96 \text{ kgfm} \leq 58 \text{ kgfm}$$

$x_1 \ y_1 \ z_1$ – x, y and z direction length of block m1

$x_2 \ y_2 \ z_2$ – x, y and z direction length of block m2

$x_3 \ y_3 \ z_3$ – x, y and z direction length of block m3

L_{x1}, L_{y1}, L_{z1} – Weight center location of block m1 from B axis rotation center

L_{x2}, L_{y2}, L_{z2} – Weight center location of block m2 from B axis rotation center

L_{x3}, L_{y3}, L_{z3} – Weight center location of block m3 from B axis rotation center

$J_{xx1}, J_{yy1}, J_{zz1}$ – Inertia moment by x, y and z axis from the weight center of block m1

$J_{xx2}, J_{yy2}, J_{zz2}$ – Inertia moment by x, y and z axis from the weight center of block m2

J_{xx3} , J_{yy3} , J_{zz3} – Inertia moment by x, y and z axis from the weight center of block m3

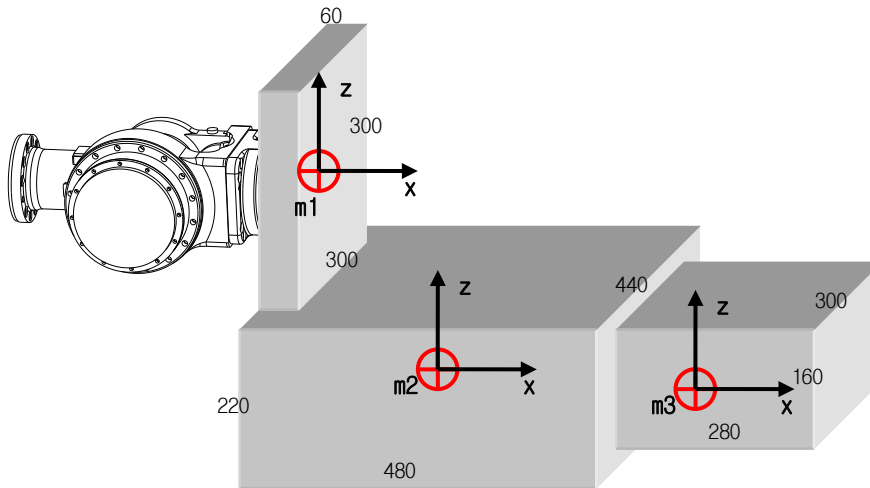


Figure 3.9 3-D load model 3-D shape

③ Permitted inertia moment limit

Table 3-4 Inertia moment from weight center by block

Block weight (kg)	Weight center (L_x , L_y , L_z)	J_{xx}	J_{yy}	J_{zz}
m₁ (14.6)	(0.25, 0, 0)	0.219 kgm ²	0.114 kgm ²	0.114 kgm ²
m₂ (125.4)	(0.48, 0, -0.26)	2.530 kgm ²	2.915 kgm ²	4.433 kgm ²
m₃ (36.3)	(0.89, 0, -0.26)	0.350 kgm ²	0.314 kgm ²	0.509 kgm ²

B axis inertia moment (J_{a5})

$$\begin{aligned}
 J_{a5} &= \sum_i [m_i (L_{xi}^2 + L_{zi}^2) + J_{yyi}] \\
 &= [14.6 \times (0.25^2) + 0.114] + [125.4 \times (0.46^2 + 0.26^2) + 2.915] \\
 &\quad + [36.3 \times (0.85^2 + 0.26^2) + 0.314] = 67.95 \leq 106 \text{ kgm}^2
 \end{aligned}$$

R1 axis inertia moment (J_{a6})

$$\begin{aligned}
 J_{a6} &= \sum_i [m_i (L_{yi}^2 + L_{zi}^2) + J_{xxi}] \\
 &= [14.6 \times (0^2) + 0.219] + [125.4 \times (0.26^2) + 2.530] \\
 &\quad + [36.3 \times (0.26^2) + 0.350] = 14.03 \leq 56 \text{ kgm}^2
 \end{aligned}$$

④ Conclusion

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

3.6. Recommended Standby Posture

Selecting a good standby posture can save energy and reduce motor temperature.

If the tool is positioned as the figure below, the load on H and V-axes may be minimized.

In case that the posture shown below might not be attained due to the limited space and time caused by peripheral equipment or cycle times, then contact our company.

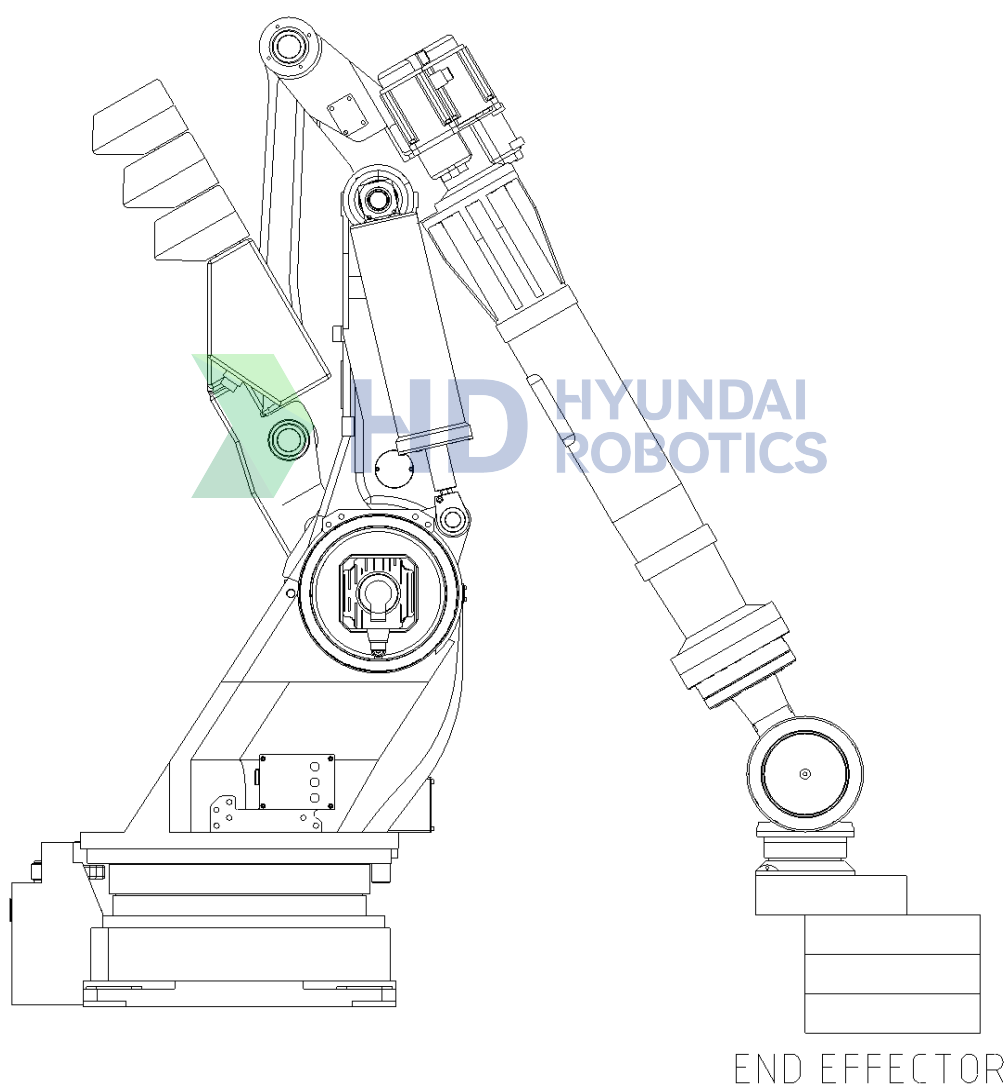


Figure 3.10 Recommended Standby Posture





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Inspection



4. Inspection

HX400L

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

4.1. Inspection Item and Period

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	MANIPULATOR, MOTOR, REDUCER
Regular inspection	3months	WIRING, BOLTS, REDUCER
	1 year	LIMIT SWITCH / DOG, BRAKE

4.2. Inspection Item and Period

Table 4-2 Inspection Items and Periods

No.	Inspection Intervals			Inspection Items	Inspection method	Standards	Remark
	Daily	3 months	1 year				
Robot Manipulator and Axes common							
1	○			Cleaning	Examine dirt and dust with naked eyes		
2		○		Inspection wiring	Examine any cable damages Examine cable fixing bracket tightening bolts paint marking with naked eyes Examine any cable cover damages with naked eyes		
3		○		Main bolts	Examine paint marking with naked eyes		
4			○	Limit Switch/ Dog	Check the ON-OFF function of limit switch	Check if the emergency stop lamp is on when the limit switch is ON.	
5	○			Motor	Check the abnormal heating Check the abnormal sound		
6			○	Brake	Check the ON/OFF operation of brake release switch Note) Turn the switch off in a second because the ARM of working axis may be dropped when the brake release switch is on	When the brake release switch is OFF, ARM of End Effect will not be dropped.	
Axis S, H, V							
7	○			Reducer	Check the abnormal sound Check the shaking(vibrating)		
Axis R2, B, R1							
8		○		Reducer	Check the abnormal sound Check the vibrating		
9		○		End Effect tightening	Examine paint marking with naked eyes		

No.	Inspection Intervals			Inspection Items	Inspection method	Standards	Remark
	Daily	3 months	1 year				
				bolts			
10		○		Diversion	there is any diversion by rotating each axis to the right and reverse direction	should not feel diversion by touch	

- If the robot is 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, reducer, etc)



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,V axis reducer case attachment	10	R2 axis reducer attachment
2	H,V axis motor attachment	11	Wrist attachment
3	Hinge and Link attachment	12	B axis reducer attachment
4	Balance Spring attachment	13	Wrist CAP attachment
5	R1 axis motor attachment	14	MECHANICAL INTERFACE attachment
6	R2 axis motor attachment	15	Wrist COVER attachment
7	B axis motor attachment	16	R1 axis reducer attachment
8	Arm Pipe attachment	17	End-effector attachment
9	Upper arm and Link attachment		

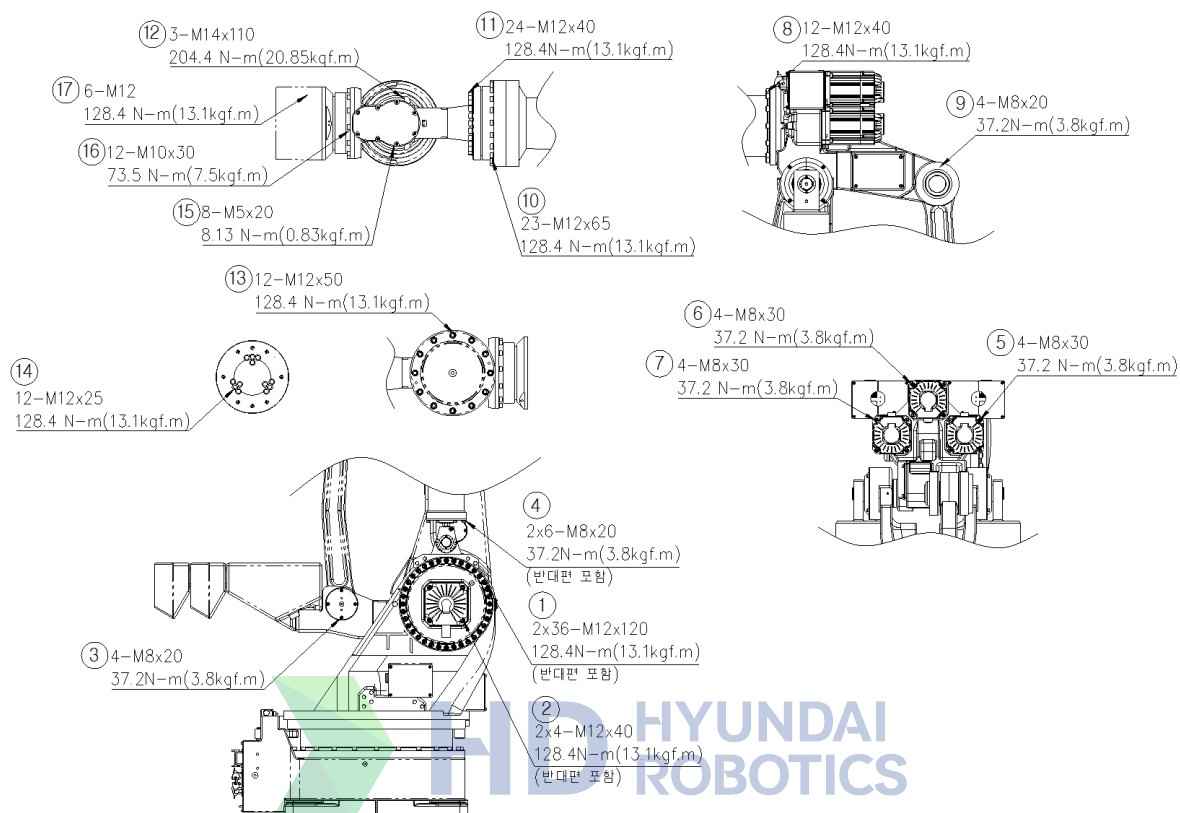


Figure 4.1 Inspection Part for Main Bolts

4.4. Inspection of Wrist Backlash

Check a diversion by forcing the end-effector (End Effector : spot gun, hand device, etc.), which is attached to the vertical hem of Wrist, in the direction of back and forth, right and left, and up and down.

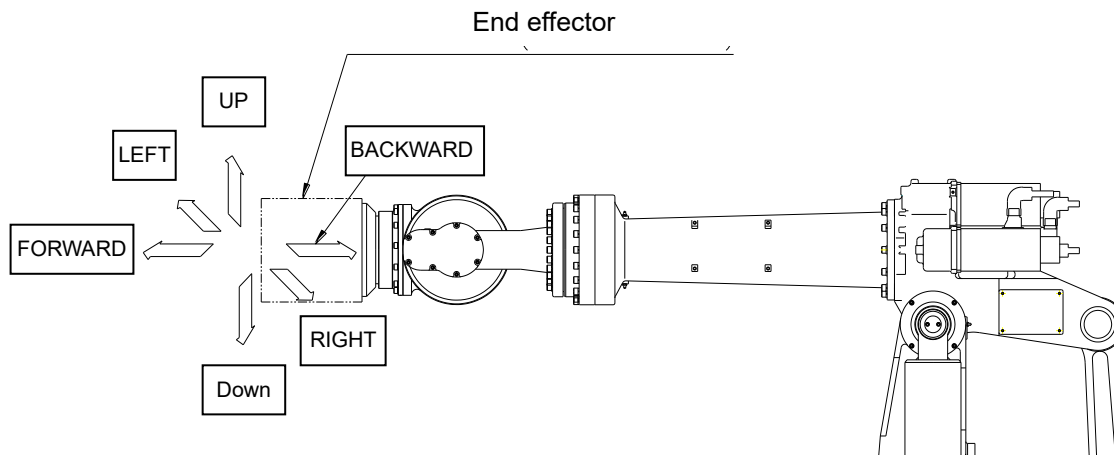


Figure 4.2 Abnormal Backlash Inspecting Directions



4.5. Inspection Internal Wiring

Flexible cables are used for internal wiring of robot manipulator. However, when an internal cable is broken or crushed, the robot may malfunction. Therefore, regular inspection is required. When operating in the working envelope according to following inspection conditions, inspection must be completed in advance.

4.5.1. The Conditions of Safety Inspection

When performing the operating work such as teaching (except shutting off driving source of industrial robot) in the working envelope, check the following articles before the work. If abnormality is found, correct the problem on the spot and then take necessary actions.

- Check if the covered wire and sheathing are damaged or not.
- Check if the manipulator can be operated or not.
- Check emergency stop function



4.5.2. Inspection Part

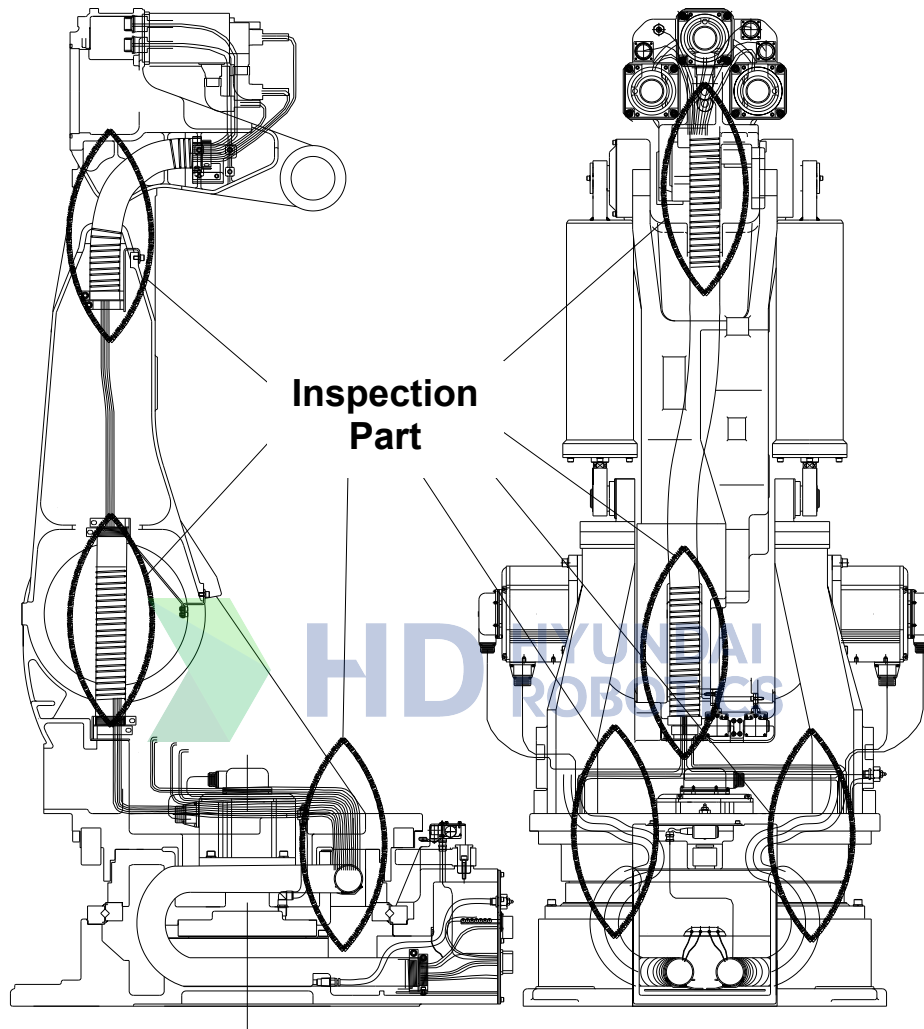


Figure 4.3 Cable Inspection Parts





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Maintenance



5. Maintenance

HX400L

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) Make sure to wear safety glasses before injecting grease and inspection.
- (2) Before starting to grease, remove the plug from the grease outlet.
- (3) When loosening a plug, grease and the plug could be discharged. Block the outlet with a thick cloth to prevent injuries caused by discharged grease or plug, and keep a distance away for safety. (Do not look into the grease outlet.)
- (4) Whenever possible, avoid using a compressed-air pump, powered by the factory air supply. If the use of a compressed-air pump is unavoidable, restrict the greasing pressure less than 1.5bar(1.5kgf/cm², 0.15MPa)
- (5) Use grease only of the specified type. If not, may damage the reducer or lead to other problems.
- (6) After greasing, check if there is any leakage and pressure. Remove the remaining pressure as suggested and connect the plug.
- (7) To prevent accidents caused by slipping, completely remove any excess grease from the floor or robot.
- (8) When an ambient temperature is more than 35°C, be sure to shorten the period of replenishment in half.
- (9) Tip for preoutleting leakage due to overpressure and over injection of grease in the reducer
 - 1) When adding or replacing grease, add as much grease as you have drained.
 - 2) Open the outlet after every 6,000 hours of operation to remove the pressure in the reducer.

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

- (1) Attach a grease receiver or a hose to the grease outlet to prevent contamination from discharged grease.
- (2) Operate it within a range without surrounding and interference under the following conditions.

Axis	Operation angle (1 axis /2 axis /3 axis)	Operation speed	Operation time
1 axis ~ 3 axis	80° /90° /70° or more	100 %	Minimum of 20 minutes
4 axis ~ 6 axis	60° /120° /60° or more	100 %	Minimum of 20 minutes
Arm gear box	60° /120° /60° or more	100 %	Minimum of 20 minutes

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

■ Periodic Replenishment / Replacement

Grease exchange cycle

- ✓ S-Axis Reducer : every 24,000 hours
- ✓ Other Reducers : every 12,000 hours
- ✓ Bearing : every 6 months
- ✓ Arm Frame gear box : After every 6-7 years (or after an overhaul)

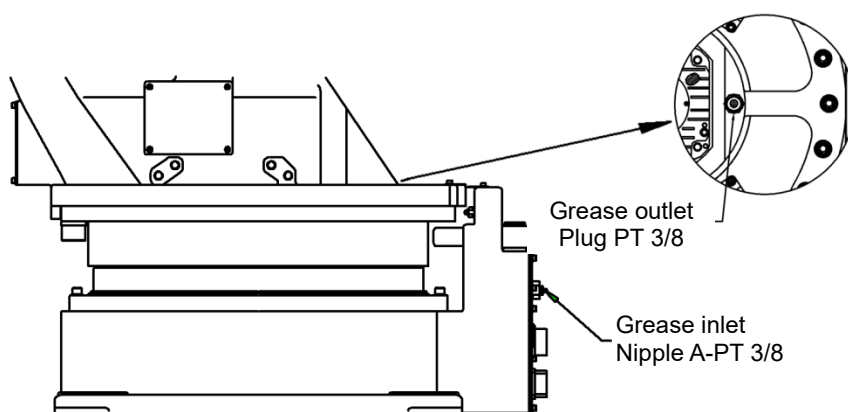
If there is still noise in the reducer even after using specified grease, check the state closely for 1-2 days during operation. Generally, the noise will go away.

(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-Axis Reducer



Attention

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

■ Grease Replacement

- (1) Remove the grease outlet plug.
- (2) Inject the grease into the grease inlet using a grease gun.

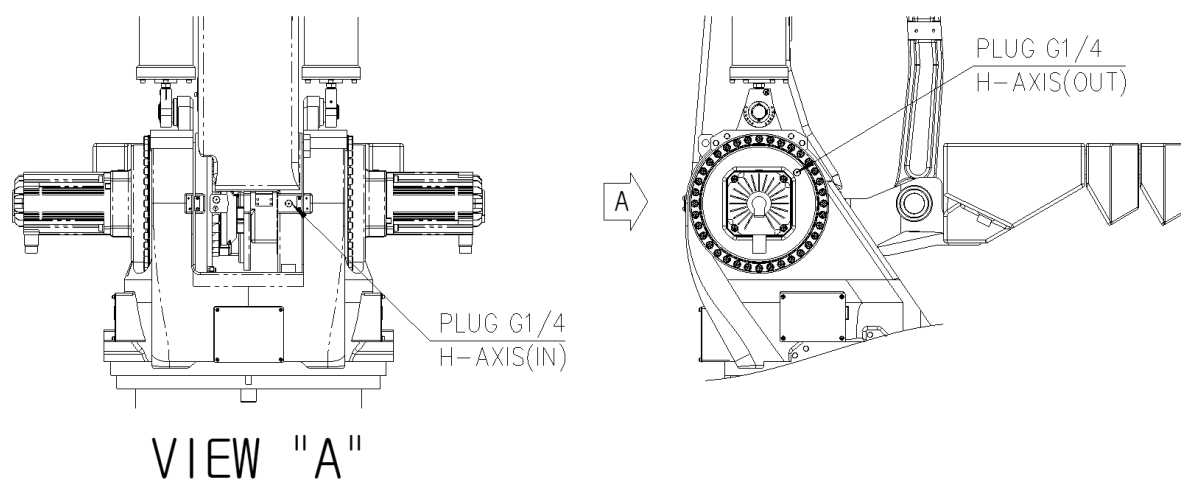
- ✓ Grease type : VIGO GREASE RE0
- ✓ Amount of grease : 3,650cc

- (3) The grease replacement is complete when new grease appears in the outlet port. The new grease can be distinguished from the old one by color.
- (4) Discharge excessively fueled grease and residual pressure. (Refer to the discharge procedure below.)
- (5) Clean the greased around the outlet and assemble the seal-taped plug into its original state.

- **Procedure in discharging excessively fueled grease and residual pressure after grease replacement and injection**
 - (1) Attach a grease receiver or a hose to the grease outlet to prevent contamination from discharged grease.
 - (2) Operate it within a range without surrounding and interference under the following conditions.
 - ① Operation angle : 80° or more
 - ② Operation speed : 100%
 - ③ Operation time: 20 minutes or more
 - (3) Wipe the outlet port with a cloth and attach the plug.



5.1.2. H-Axis Reducer



Attention

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

■ Grease Replacement

- (1) Make the H-Axis Arm vertical for ground.(H:90° -Floor Type, H:0° -Shelf Type)
- (2) Remove the grease outlet plug.
- (3) Inject the grease into the grease inlet using a grease gun.

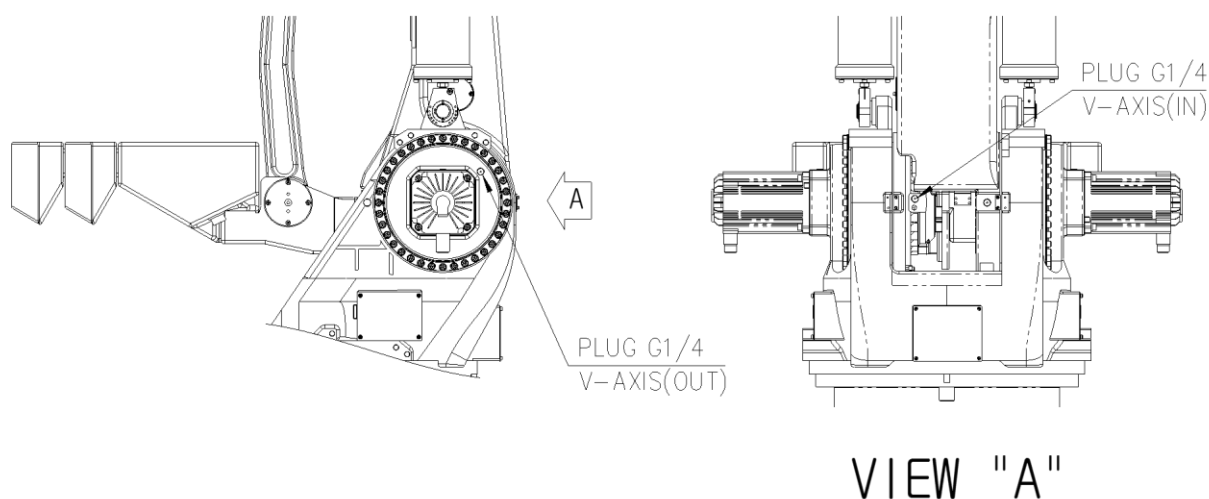
- ✓ Grease type : VIGO GREASE RE0
- ✓ Amount of grease : 3,300cc

- (4) The grease replacement is complete when new grease appears in the outlet port. The new grease can be distinguished from the old one by color.
- (5) Discharge excessively fueled grease and residual pressure. (Refer to the discharge procedure below.)
- (6) Clean the greased around the outlet and assemble the seal-taped plug into its original state.

- **Procedure in discharging excessively fueled grease and residual pressure after grease replacement and injection**
 - (1) Attach a grease receiver or a hose to the grease outlet to prevent contamination from discharged grease.
 - (2) Operate it within a range without surrounding and interference under the following conditions.
 - ① Operation angle : 90° or more
 - ② Operation speed : 100%
 - ③ Operation time: 20 minutes or more
 - (3) Wipe the outlet port with a cloth and attach the plug.



5.1.3. V-Axis Reducer



Attention

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

■ Grease Replacement

- (1) Make the V-Axis Arm horizontal for ground.(V:0° -Floor Type, V:-90° -Shelf Type)
- (2) Remove the grease outlet plug.
- (3) Inject the grease into the grease inlet using a grease gun.

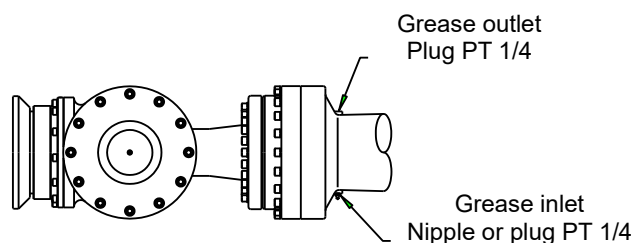
- ✓ Grease type : VIGO GREASE RE0
- ✓ Amount of grease : 3,300cc

- (4) The grease replacement is complete when new grease appears in the outlet port. The new grease can be distinguished from the old one by color.
- (5) Discharge excessively fueled grease and residual pressure. (Refer to the discharge procedure below.)
- (6) Clean the greased around the outlet and assemble the seal-taped plug into its original state

- **Procedure in discharging excessively fueled grease and residual pressure after grease replacement and injection**
 - (1) Attach a grease receiver or a hose to the grease outlet to prevent contamination from discharged grease
 - (2) Operate it within a range without surrounding and interference under the following conditions
 - ① Operation angle : 70° or more
 - ② Operation speed : 100%
 - ③ Operation time: 20 minutes or more
 - (3) Wipe the outlet port with a cloth and attach the plug.



5.1.4. R2-Axis Reducer



Attention

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

■ Grease Replacement

- (1) Prepare a grease nipple A-PT1/4.
- (2) Remove the grease outlet plug.
- (3) Remove the grease inlet plug and install grease nipple A-PT1/4.
- (4) Inject the grease into the grease inlet using a grease gun.

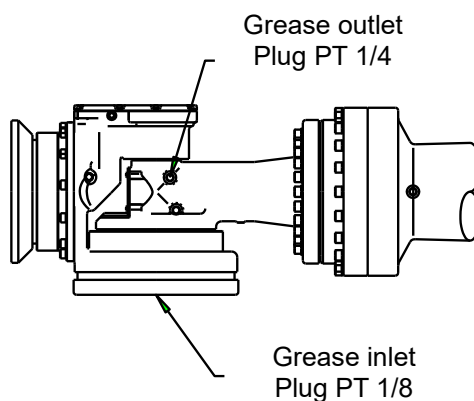
- ✓ Grease type : VIGO GREASE RE0
- ✓ Amount of grease : 1,100cc

- (5) The grease replacement is complete when new grease appears in the outlet port. The new grease can be distinguished from the old one by color.
- (6) Discharge excessively fueled grease and residual pressure. (Refer to the discharge procedure below.)
- (7) Clean the greased around the outlet and assemble the seal-taped plug into its original state

- **Procedure in discharging excessively fueled grease and residual pressure after grease replacement and injection**
 - (1) Attach a grease receiver or a hose to the grease outlet to prevent contamination from discharged grease.
 - (2) Operate it within a range without surrounding and interference under the following conditions.
 - ① Operation angle : 60° or more
 - ② Operation speed : 100%
 - ③ Operation time: 20 minutes or more
 - (3) Wipe the outlet port with a cloth and attach the plug.



5.1.5. B-Axis Reducer



Attention

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

■ Grease Replacement

- (1) Prepare a grease nipple A-PT1/8 and then make the R2-Axis 0° degree.
- (2) Remove the grease inlet plug and install grease nipple A-PT1/8.
- (3) Make the R2-Axis -90° degree and then remove the grease outlet plug.
- (4) Inject the grease into the grease inlet using a grease gun.

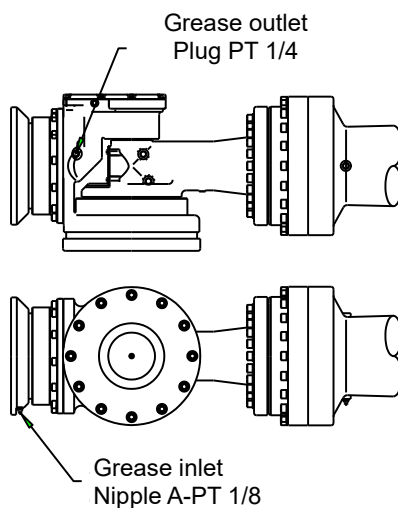
- ✓ Grease type : VIGO GREASE RE0
- ✓ Amount of grease : 950cc

- (5) The grease replacement is complete when new grease appears in the outlet port. The new grease can be distinguished from the old one by color.
- (6) Discharge excessively fueled grease and residual pressure. (Refer to the discharge procedure below.)
- (7) Clean the greased around the outlet and assemble the seal-taped plug into its original state.

- **Procedure in discharging excessively fueled grease and residual pressure after grease replacement and injection**
 - (1) Attach a grease receiver or a hose to the grease outlet to prevent contamination from discharged grease.
 - (2) Operate it within a range without surrounding and interference under the following conditions.
 - ① Operation angle : 120° or more
 - ② Operation speed : 100%
 - ③ Operation time: 20 minutes or more
 - (3) Wipe the outlet port with a cloth and attach the plug.



5.1.6. R1-Axis Reducer



Attention

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

■ Grease Replacement

- (1) Remove the grease outlet plug.
- (2) Inject the grease into the grease inlet using a grease gun.

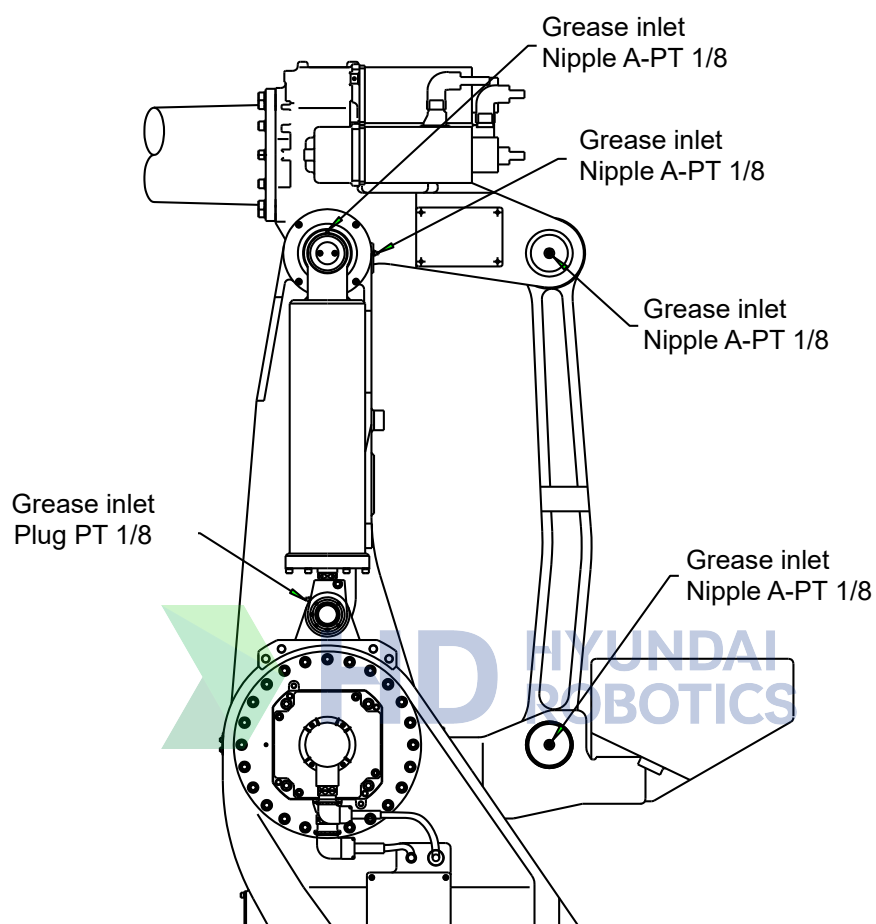
- ✓ Grease type : VIGO GREASE RE0
- ✓ Amount of grease : 435cc

- (3) The grease replacement is complete when new grease appears in the outlet port. The new grease can be distinguished from the old one by color.
- (4) Discharge excessively fueled grease and residual pressure. (Refer to the discharge procedure below.)
- (5) Clean the greased around the outlet and assemble the seal-taped plug into its original state.

- **Procedure in discharging excessively fueled grease and residual pressure after grease replacement and injection**
 - (1) Attach a grease receiver or a hose to the grease outlet to prevent contamination from discharged grease.
 - (2) Operate it within a range without surrounding and interference under the following conditions.
 - ① Operation angle : 60° or more
 - ② Operation speed : 100%
 - ③ Operation time: 20 minutes or more
 - (3) Wipe the outlet port with a cloth and attach the plug.



5.1.7. Bearing supporter



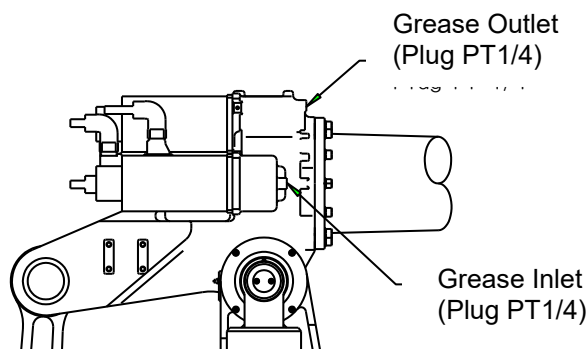
■ Grease Replenishment

- ① Prepare a grease nipple A-PT1/8.
- ② When necessary, remove the inlet plug and assemble the nipple A-PT1/8.
- ③ Inject the grease into the grease inlet using a grease gun.

- ✓ Grease type : Gadus S3 V220C 2
- ✓ Amount of grease : 5cc

- ④ Remove grease nipple A-PT1/8 from grease inlet port.

5.1.8. A1 Frame - Gear Box



■ Grease Replacement

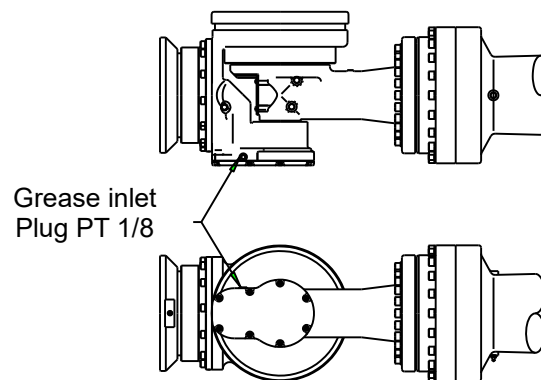
- (1) In the case of an arm frame gearbox, do not replace grease until after 6–7 years (or after an overhaul), which is the normal replacement interval.
- (2) When replacing all the grease in the gearbox, remove the used grease by dismounting the R2/B/R1-shaft motor. Then, fill with new grease. For the detailed work method, contact us. (When dismounting the motor, the point of origin should be realigned because the tool position will be changed.)

- ✓ Grease type: GADUS S2 V46 2
- ✓ Amount of grease: 1,900 cc (1,710 g)

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

Arm gear box	60° /120° /60° or more	100 %	Minimum of 20 minutes
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5.1.9. Wrist - Gear Box



■ Grease Replacement

- (1) Prepare a grease nipple A-PT1/8.
- (2) Remove the grease inlet plug and install grease nipple A-PT1/8.
- (3) Inject the grease into the grease inlet using a grease gun.

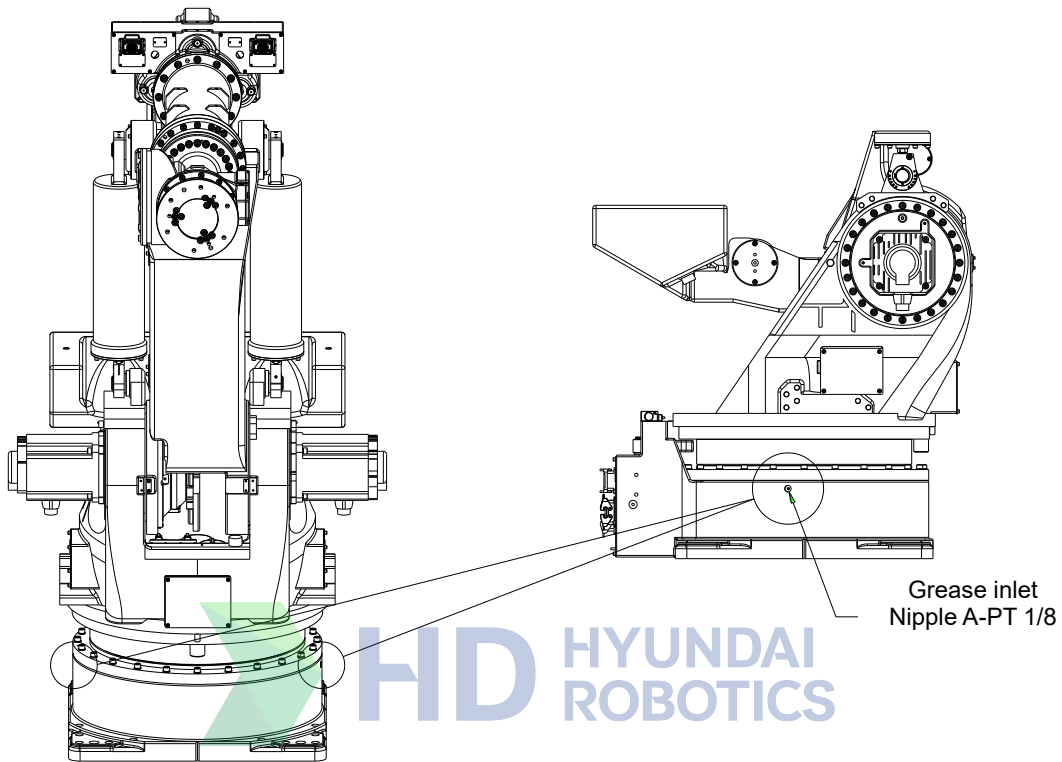
- ✓ Grease type: Gadus S2 V46 2
- ✓ Amount of grease: 267cc(240g)

- (4) Remove grease nipple A-PT1/8 from grease inlet port.
- (5) Discharge excessively fueled grease and residual pressure. (Refer to the discharge procedure below.)
- (6) Clean the grease around the outlet and assemble the seal-taped plug into its original state.

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

- (1) Attach a grease receiver or a hose to the grease outlet to prevent contamination from discharged grease.
- (2) Operate it within a range without surrounding and interference under the following conditions.
 - ① Operation angle : R1-Axis, 60° or more
 - ② Operation speed : 100%
 - ③ Operation time: 20 minutes or more
- (3) Wipe the outlet port with a cloth and attach the plug.

5.1.10. S Axis Cross Roller bearing



■ Grease Replenishment

- (1) Prepare a grease nipple A-PT1/8
- (2) Remove any foreign substances on the inlet of the nipple if needed.
- (3) Inject the grease into the grease inlet using a grease gun

- ✓ Grease type: Gadus S3 V220C 2
- ✓ Amount of grease: 5cc (Max. 15cc)

- (4) Remove grease nipple A-PT1/8 from grease inlet port

5.2. Battery Replacement

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

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



Attention

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

- ② Detach the battery cover.
- ③ Take out the old batteries from the battery cover.
- ④ Insert new batteries into it. Pay attention to the direction of batteries.

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

- ⑤ Reinstall the battery cover.

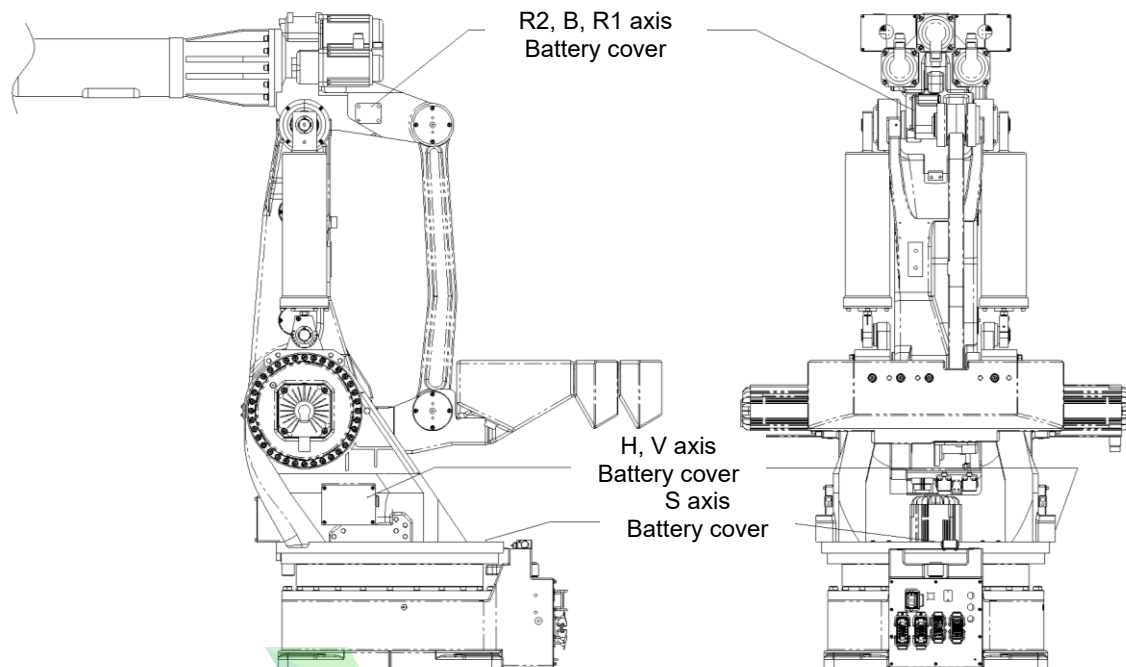


Figure 5.1 Location of Battery Replacement



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

5.2.1. Instructions for Battery Storage

- (1) Do not keep the batteries at a high temperature and humidity. Keep it in the well-ventilating place without dew condensation
- (2) Keep it in a normal temperature, at relatively constant temperature($20 \pm 15^{\circ}\text{C}$) and at relative humidity of less than 70%
- (3) Check the battery storage every six months, and manage them with first-in-first-out



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 16,000 operating hours regardless of working condition

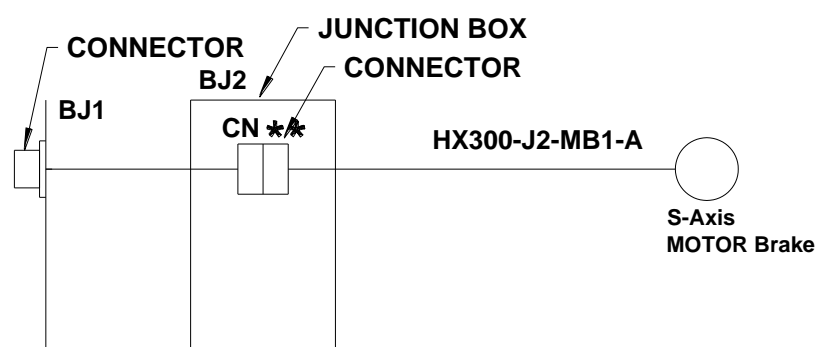


Attention

- ✓ 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.

5.3.1. Wiring Connection Diagram

Refer to [Figure 5.2] for part symbols of the internal wiring.



HX300 - J2 - MB1 - A

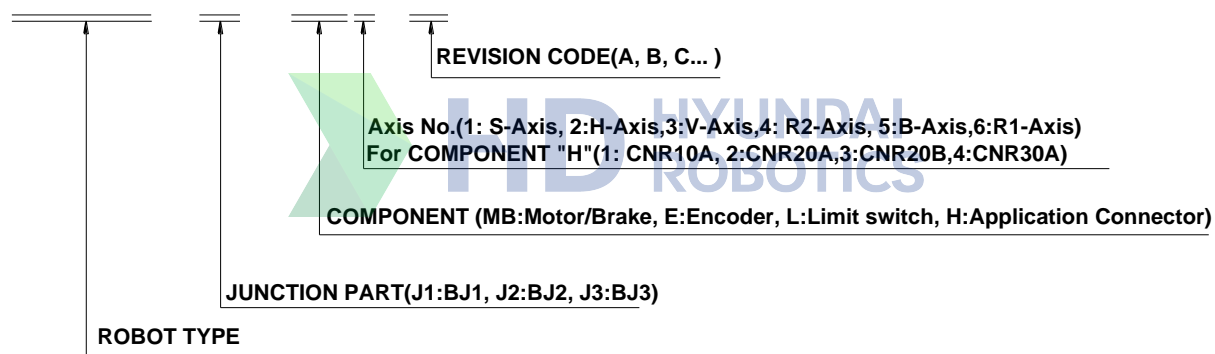


Figure 5.2 Explains of internal wiring







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Troubleshooting



6. Troubleshooting

HX400L

6.1. Troubleshooting Procedure

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

(1) Step 1 : Which axis occurs the problem?

First of all, check which axis causes the malfunction. In case that it is hard to detect the problem, check the following possible mechanical defaults.

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

(2) Step 2 : Which parts have been damaged?

If the abnormal axes are determined, investigate which parts cause trouble. There could be many causes for one phenomenon. Refer to [Table 6-1] for the cause and phenomenon of the trouble.

(3) Step 3 : Dealing with malfunction parts

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

6.2. Trouble Symptoms and Possible Causes

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

Table 6-1 Trouble phenomenon and cause

Defect parts Trouble phenomenon	Reducer	Brake	Motor	Encoder	Fulcrum bearing
Overload [Note 1]	○	○	○		○
Displacement	○		○	○	
Abnormal sound occurrence	○	○	○		○
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.

6.3. Diagnostics and Resolutions for Major Parts Failure

6.3.1. Fulcrum Bearings

Vibration, abnormal sound and overloads are observed when a fulcrum bearing is damaged. When the Nut holding bearings becomes loose, bearing play occurs. It may damage the bearings.

■ Diagnostics

- ① Shake the ARM Pipe and Upper Frame back and forth to check if bearing exhibits any play. (In case of using a chain block, check the bearings for the play, with the Arm Pipe and Upper Frame posture maintaining and without any overload to the reducer.)
- ② Check to see if the robot touched other peripheral equipment before the malfunction.

■ Resolution

Replace the bearing. A Chain Block is needed to lift and hang the robot ARM. Contact our service office for any difficulties.



6.3.2. 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 Check out any vibration, abnormal sound or overheating of the reducer when the robot is in operation.
- ② Check out any play and abrasion in the reducer. And check if any abnormality is felt by hand when shaking 1st ARM back and forth with the brake release switch of axis S [ON].
- ③ 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

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 check 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)

6.3.3. 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.



6.3.4. 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.

6.3.5. 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



6.4. 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 Weight of motor for each model

Robot model	Weight of main axes motor	Weight of wrist axes motor
HX400L	30.7 kg	10.0 kg

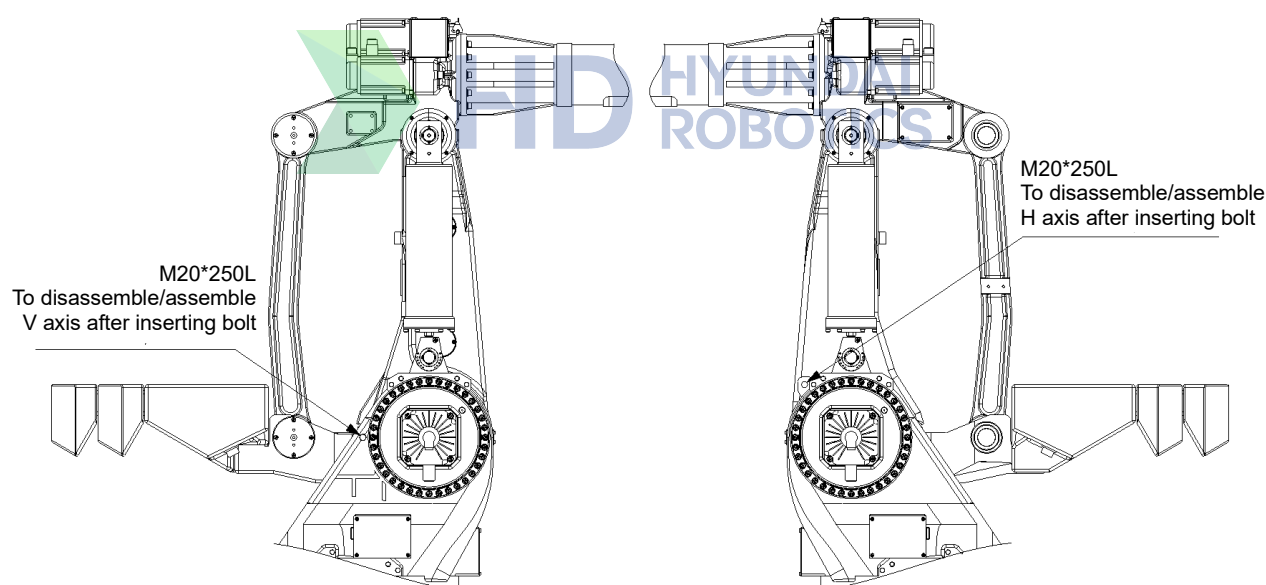


Figure 6.1 How to prevent dropping of ARM Axis H & V



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 perform the work quickly and carefully. An escape route should be determined before starting work.

After replacing axis H or V, ensure that M20 bolt for supporting ARM has been removed before operating the robot.

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	M12 Torque wrench(Lock type)	Use torque wrench and extension on the market
	R2, B, R1	M8 Torque wrench (Lock type) M5 Torque wrench (Lock type)	

Table 6-4 Necessary parts

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



6.4.2. How to Replace Motor

- (1) Put the controller into TEACH mode and select motors [ON]. When the motors [On] state cannot be obtained, check the respective ARM is firmly fixed while supporting it to prevent dropping. And then begin at step No.4.
- (2) The axis requiring motor replacement takes basic posture.
- (3) In case of main axes(S, H, V) : Refer to [Figure 6.1] .
Insert a supporting bolt to prevent ARM dropping.
In case of wrist axes (R2, B, R1) : Set the origin by using SCALES.
- (4) Turn the main power [OFF] with the controller power [OFF].
- (5) Disconnect the connector from the motor.
- (6) Remove attachment bolts of motor and pull the motor out of robot. When removing motors of axis H or V, be sure not to damage the lip of oil seal due to the gear attached to the axis of motor.
- (7) Detach the gear from the motor shaft. not give excessive impact to the motor shaft.
- (8) Assemble the gear after lightly applying grease to the shaft.
The bolt used to attach the gear to the shaft should be cleaned and removed of grease before using. Apply loctite 243 to the screw part of the bolt, and then tighten it using a torque wrench in a regular torque. , Besides, slowly tighten the bolt in a symmetrical order.
- (9) Assemble the motor on the robot after applying a small amount of grease to the lip of oil seal and applying a moderate amount of grease to the teeth of gear. When assembly the main axis motor, be sure not to damage the lip of oil seal.
- (10) Connect the connector to the motor.
- (11) When replacing the axis H or V, replenish the grease as the amount as it lost.
- (12) Reset the encoder of the axis whose motor is replaced.



Warning

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

- (13) Perform the encoder calibration about the axis whose motor is replaced. Refer to the chapter [Encoder Calibration] in the controller operating manual..
- (14) Remove M20 bolt, a supporting bolt for preventing possible dropping of axis H.
- (15) Confirm that there is no error in robot's motion.



6.5. Encoder Zero Setting

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

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



Warning

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

An escape route should be determined before starting work



6.5.1. Zero Setting

- (1) Put the controller into TEACH mode and select [MOTOR ON]. If you cannot select MOTOR ON due to abnormality, set the origin position of the robot by using the brake release switch.
- (2) Move respective axes to the basic posture, 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』.
- (5) Confirm that there is no problem in robot motion.

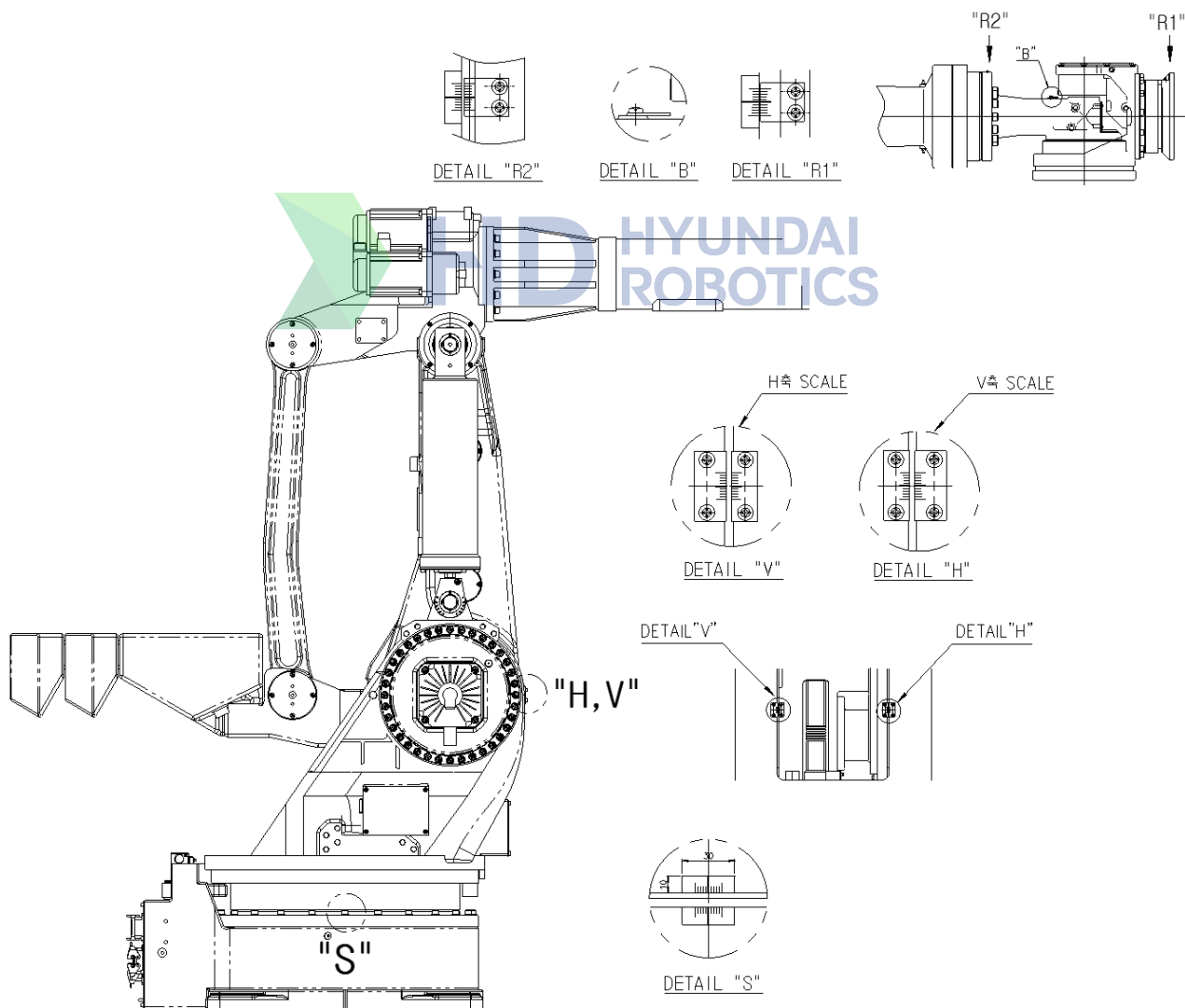
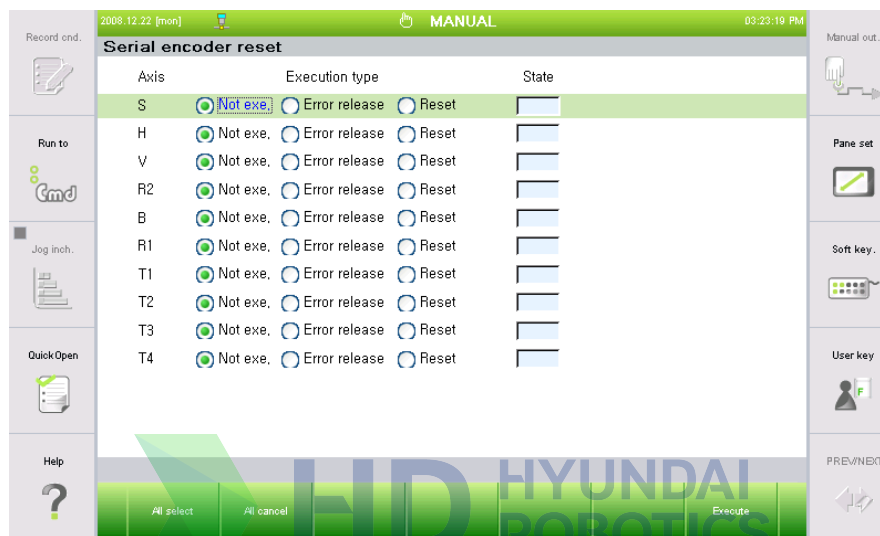


Figure 6.2 Method of Zero Setting

6.5.2. Encoder Reset

- (1) Turn off the motor.
- (2) Open the serial encoder reset window. (『F2』: System → 『F5』: Initialize → 『F4』: 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]

	Adjust[%s]	Current[%s]	Angle[deg]
S =	FFC00A28 [hex]	003FF5DD [hex]	0.708 [deg]
H =	FFC00803 [hex]	003FF7FD [hex]	91.230 [deg]
V =	FFC01223 [hex]	003FEDDD [hex]	1.452 [deg]
R2 =	FFC00020 [hex]	003FFFE0 [hex]	0.225 [deg]
B =	FFC00548 [hex]	003FFAB5 [hex]	-90.740 [deg]
R1 =	FFC01EFE [hex]	003FE102 [hex]	3.487 [deg]
T1 =	0008843A [hex]	FFF77BC6 [hex]	-1886.396 [mm]
T2 =	FF6F1683 [hex]	0090E97D [hex]	-2104.792 [mm]
T3 =	FFC002FA [hex]	003FFD06 [hex]	-0.116 [deg]
T4 =	FFC00EBT [hex]	003FF14F [hex]	-0.660 [deg]

After moving the selected axis with the jog key, press the [Apply] key.

Apply Apply all Complete

- (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』





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Recommended
Spare Parts



7. Recommended Spare Parts

HX400L

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

[Category]

A : Regular maintenance parts(what is replaced regularly)

B : Essential spare parts (what is of high frequency)

C : Essential component parts

D : Machine parts

Table 7-1 Spare Parts List

Category	Robot Applied	PLATE No.	Product Name and Specification	Quantity	Remark
A	HX400L	R7900004400	VIGO GREASE RE0		S, H, V Axis reducer
A	HX400L	R7900054780	GADUS S2 V46 2		R2, B, R1 Axis reducer Gears and bearings for each axis
A	HX400L	R1001-6202-001	Encoder Battery	6EA	Replace every 2 years, regardless of operating hours
B	HX400L	R3436-7111-P03	Motor	1EA	Axis S
B	HX400L	R3436-7211-P03	Motor	2EA	Common use for Axis H, V
B	HX400L	R3436-7311-P01	Motor	3EA	Common use for Axis R2, B, and R1
C	HX400L	R3436-7111-P10	Reducer	1EA	Axis S
C	HX400L	R3436-7211-P01	Reducer	1EA	Axis H
C	HX400L	R3436-7211-P02	Reducer	1EA	Axis V
C	HX400L	R3436-7311-P02	Reducer	1EA	Axis R2
C	HX400L	R3436-7411-P01	Reducer	1EA	Axis B
C	HX400L	R3436-7411-P02	Reducer	1EA	Axis R1
C	HX400L	R3436-7411-001	Wrist Ass'y	1EA	
C	HX400L	R3436-7511-001	Ass'y for the wiring of the S axis	1EA	CABLE ASSY

7. Recommended Spare Parts

Category	Robot Applied	PLATE No.	Product Name and Specification	Quantity	Remark
D	HX400L	R3436-7111-P07	OIL SEAL	1EA	S-axis INPUT GEAR
D	HX400L	R3436-7211-P04	T/R BEARING	2EA	J6 SHAFT(L)&(R)
D	HX400L	R3436-7211-P05	T/R BEARING	4EA	Lower and upper joints of V-Link
D	HX400L	R3436-7211-P06	T/R BEARING	2EA	V-axis Center Shaft
D	HX400L	R3436-7211-P07	OIL SEAL	2EA	H/V-axis Motor
D	HX400L	R3436-7211-P08	O-RING	2EA	H/V-axis motor & motor base
D	HX400L	R3436-7211-P09	O-RING	2EA	H/V-axis reducer & motor base
D	HX400L	R3436-7211-P18	O-RING	2EA	H/V-axis reducer & Each upper frame, and hinge
D	HX400L	R3436-7211-P15	V-RING	2EA	J6 shaft at the top of the upper frame
D	HX400L	R3436-7230-P01	ROLLER BEARING	4EA	BALANCE SPRING ASS'Y
D	HX400L	R3436-7230-P02	O-RING	2EA	BS TUBE ID & BS PRESSURE PLATE
D	HX400L	R3436-7230-P03	O-RING	2EA	BS ROD OD & BS PRESSURE PLATE
D	HX400L	R3436-7311-P03	BALL BEARING	3EA	R2/B/R1-axis INPUT GEAR
D	HX400L	R3436-7311-P04	BALL BEARING	2EA	R1 2 nd GEAR & IDLE GEAR (AXIS B)
D	HX400L	R3436-7311-P05	BALL BEARING	1EA	IDLE GEAR(AXIS R2)
D	HX400L	R3436-7311-P06	BALL BEARING	1EA	ARM PIPE & PIPR(AXIS R2)
D	HX400L	R3436-7311-P07	BALL BEARING	1EA	SPLINE SHAFT(AXIS R2)
D	HX400L	R3436-7311-P08	BALL BEARING	1EA	SPLINE SHAFT(AXIS B) & SPLINE SHAFT(AXIS R2)
D	HX400L	R3436-7311-P09	BALL BEARING	1EA	SPLINE PIPE(AXIS R1)
D	HX400L	R3436-7311-P10	BALL BEARING	1EA	ADAPTER(B SHAFT)

Category	Robot Applied	PLATE No.	Product Name and Specification	Quantity	Remark
D	HX400L	R3436-7311-P11	BALL BEARING	2EA	PIPE(AXIS R2)
D	HX400L	R3436-7311-P12	BALL BEARING	2EA	PIPE-2(AXIS B)
D	HX400L	R3436-7311-P13	OIL SEAL	1EA	SPLINE SHAFT(AXIS B)
D	HX400L	R3436-7311-P14	OIL SEAL	1EA	SPLINE SHAFT(AXIS R2)
D	HX400L	R3436-7311-P15	OIL SEAL	1EA	SPLINE SHAFT(AXIS R2)
D	HX400L	R3436-7311-P17	O-RING	1EA	Assembly surface of the ARM FRAME & ARM PIPE
D	HX400L	R3436-7311-P18	O-RING	1EA	ARM PIPE & R2 REDUCER
D	HX400L	R3436-7411-P03	O-RING	1EA	R1-axis BEARING HOUSING
D	HX400L	R3436-7411-P04	O-RING	1EA	R1-axis REDUCER
D	HX400L	R3436-7411-P05	O-RING	1EA	B-axis WRIST CAP
D	HX400L	R3436-7411-P06	BALL BEARING	1EA	B-axis BEVEL GEAR
D	HX400L	R3436-7411-P07	BALL BEARING	1EA	GEAR SHAFT(AXIS B)
D	HX400L	R3436-7411-P08	BALL BEARING	2EA	GEAR SHAFT(AXIS B)
D	HX400L	R3436-7411-P09	BALL BEARING	2EA	GEAR SHAFT(AXIS B)
D	HX400L	R3436-7411-P10	BALL BEARING	1EA	GEAR SHAFT(AXIS B)
D	HX400L	R3436-7411-P11	BALL BEARING	1EA	R1-axis BEARING HOUSING
D	HX400L	R3436-7411-P12	BALL BEARING	2EA	GEAR SHAFT(AXIS B)
D	HX400L	R3436-7411-P13	BALL BEARING	2EA	GEAR SHAFT(AXIS B)
D	HX400L	R3436-7411-P14	OIL SEAL	1EA	R1-axis BEARING HOUSING
D	HX400L	R3436-7411-P15	OIL SEAL	1EA	GEAR SHAFT(AXIS B)
D	HX400L	R3436-7411-P16	OIL SEAL	1EA	GEAR SHAFT(AXIS B)







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Decommission



8. Decommission

HX400L

8.1. Material for each robot part

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

Table 8-1 Materials of each part

Parts	Materials
Battery	NiCad or Lithium
Wiring, Motor	Copper
Base body, Lower Frame, Upper Frame etc.	Cast Iron
A1 pipe	Steel
Brakes, Motors	Samarium Cobalt(or Neodymium)
Wiring, Connectors	Plastic / Rubber
Reducers, Bearings	Oil / Grease
Wrist cover etc.	Aluminum alloy cast

8.2. Disposal of assembled balance spring substances

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

8.2.1. Dismantling the assembled balance spring substances

Before dismantling the assembled substances, please make sure the angle of the H-axis is placed as shown in [Figure 8.1]. The position minimizes the compression of the balance spring, allowing the robot to be dismantled. As a result, when separating the assembled balance spring substances from the main body, risk will be minimized during dismantling, as the spring compression is in equilibrium. However, the assembled balance spring substances retain high compression rates inside, meaning the assembled substances should be completely dismantled in accordance with the procedures outlined in 8.2.2.

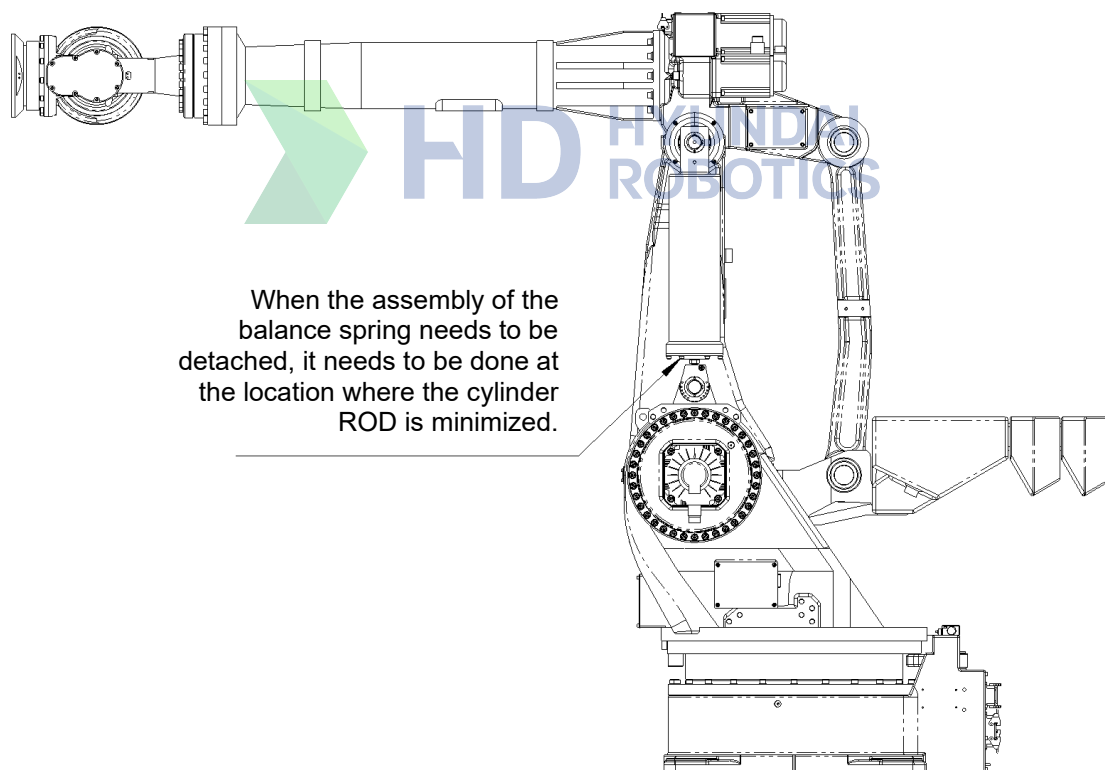


Figure 8.1 Balance spring disassembling posture

8.2.2. Disposal of assembled balance spring substances

Separated from the main body, the assembled balance spring substances retain a high compression rate inside, so they should be completely disposed of in accordance with the following procedures. Also, small amounts of grease remain inside. This grease needs to be treated with great care in an environment sensitive to pollution.

Fix the assembled balance spring substances firmly on working areas with devices such as a vice. As shown in [Figure 8.2] below, perforate the balance spring tube with an oxygen cutter. The hole shown in the Figure is the maximum size possible that can be perforated.

Cut the inside assembled spring into 4 to 5 pieces with an oxygen cutter. As two springs are assembled together, the cutting process shall be formed from the external to the internal side. After cutting, please check that there is no compression remaining in the spring.

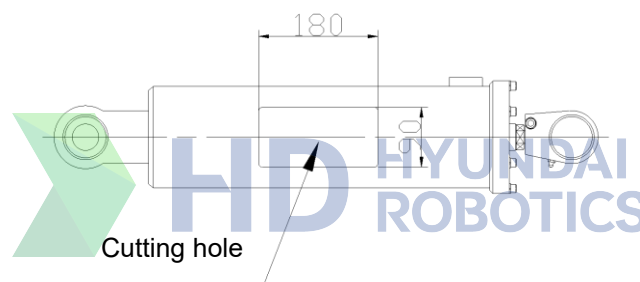


Figure 8.2 Balance spring assembly release



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Internal Wiring
Diagram

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

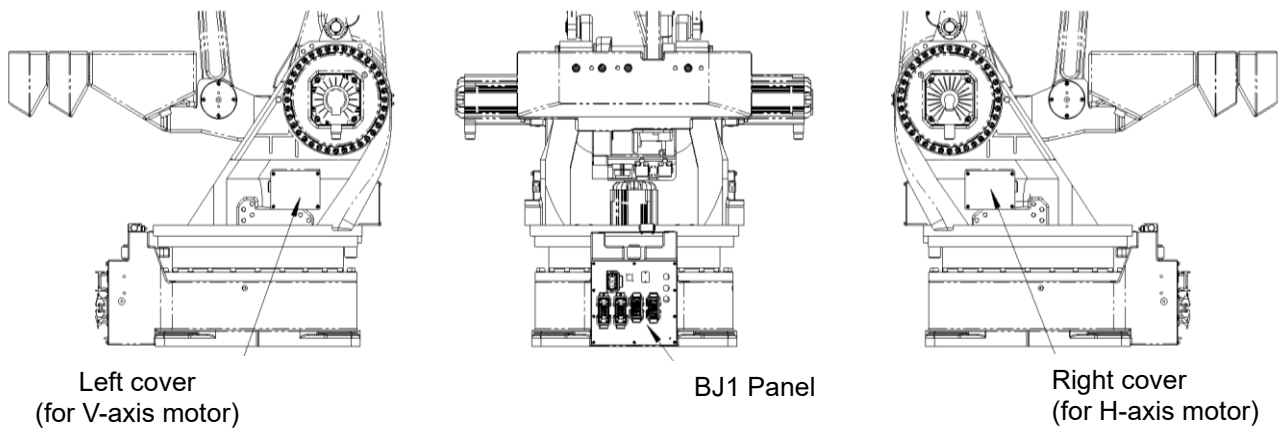
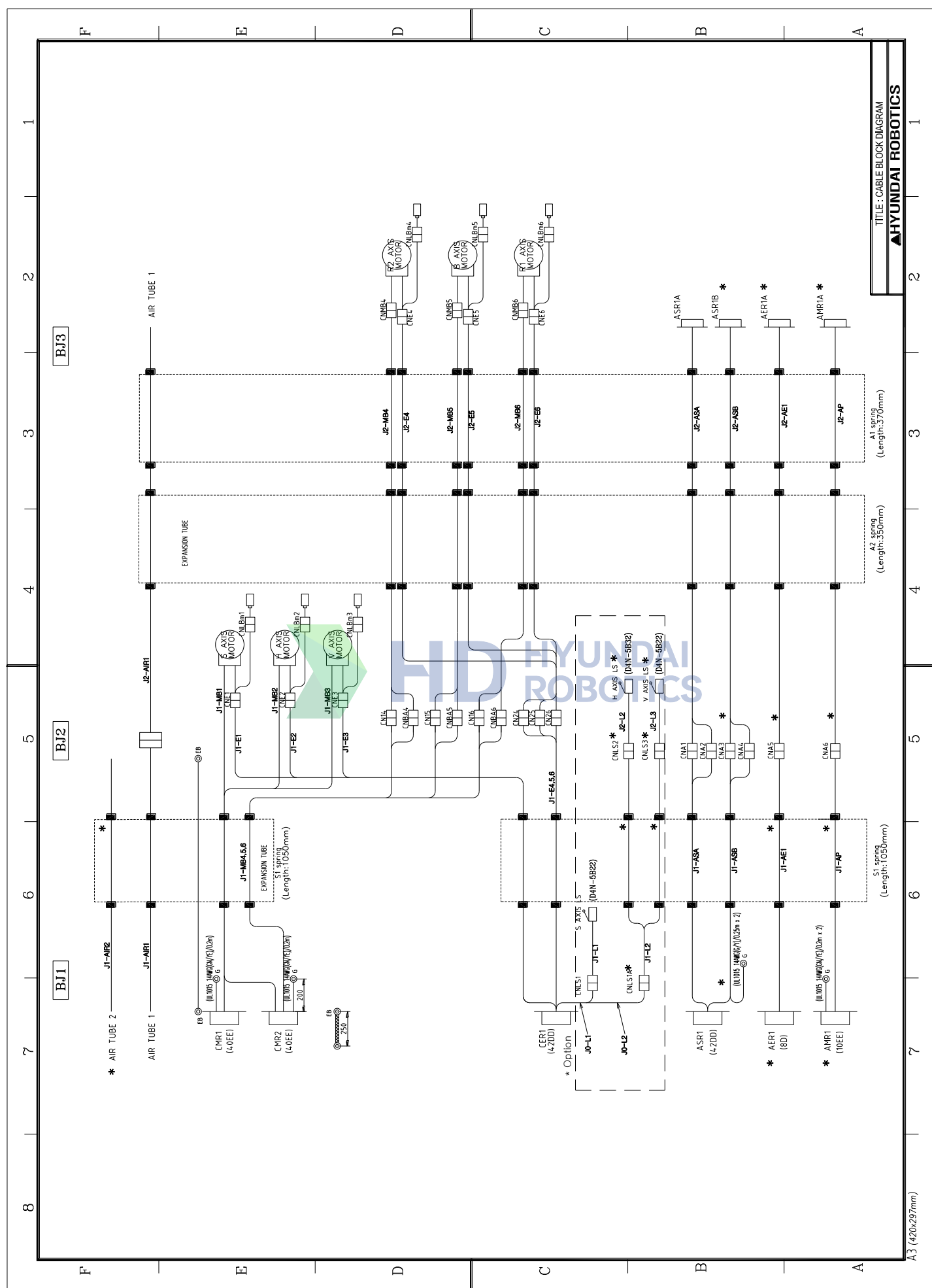


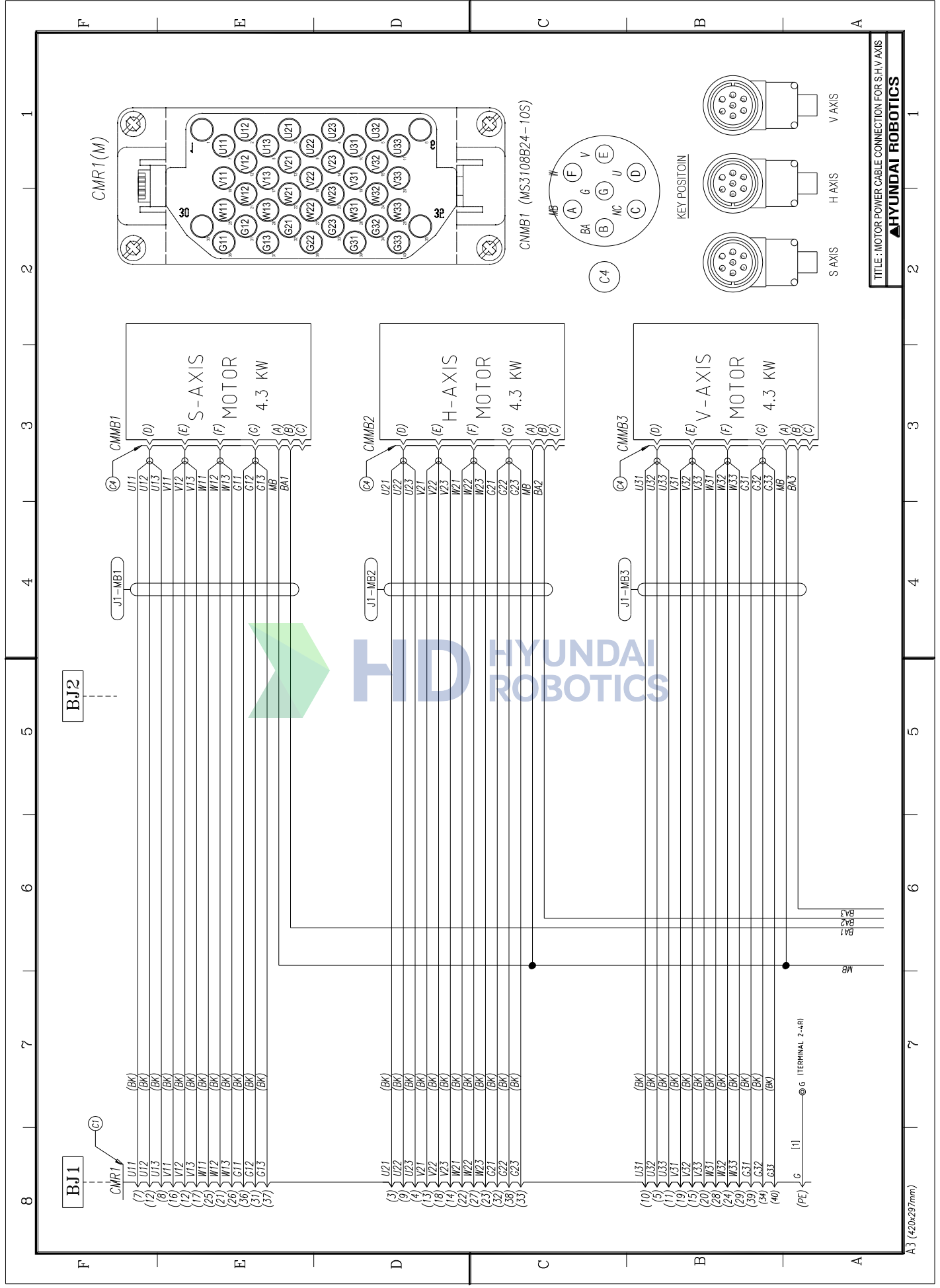
Figure 9.1 Manipulator Configuration

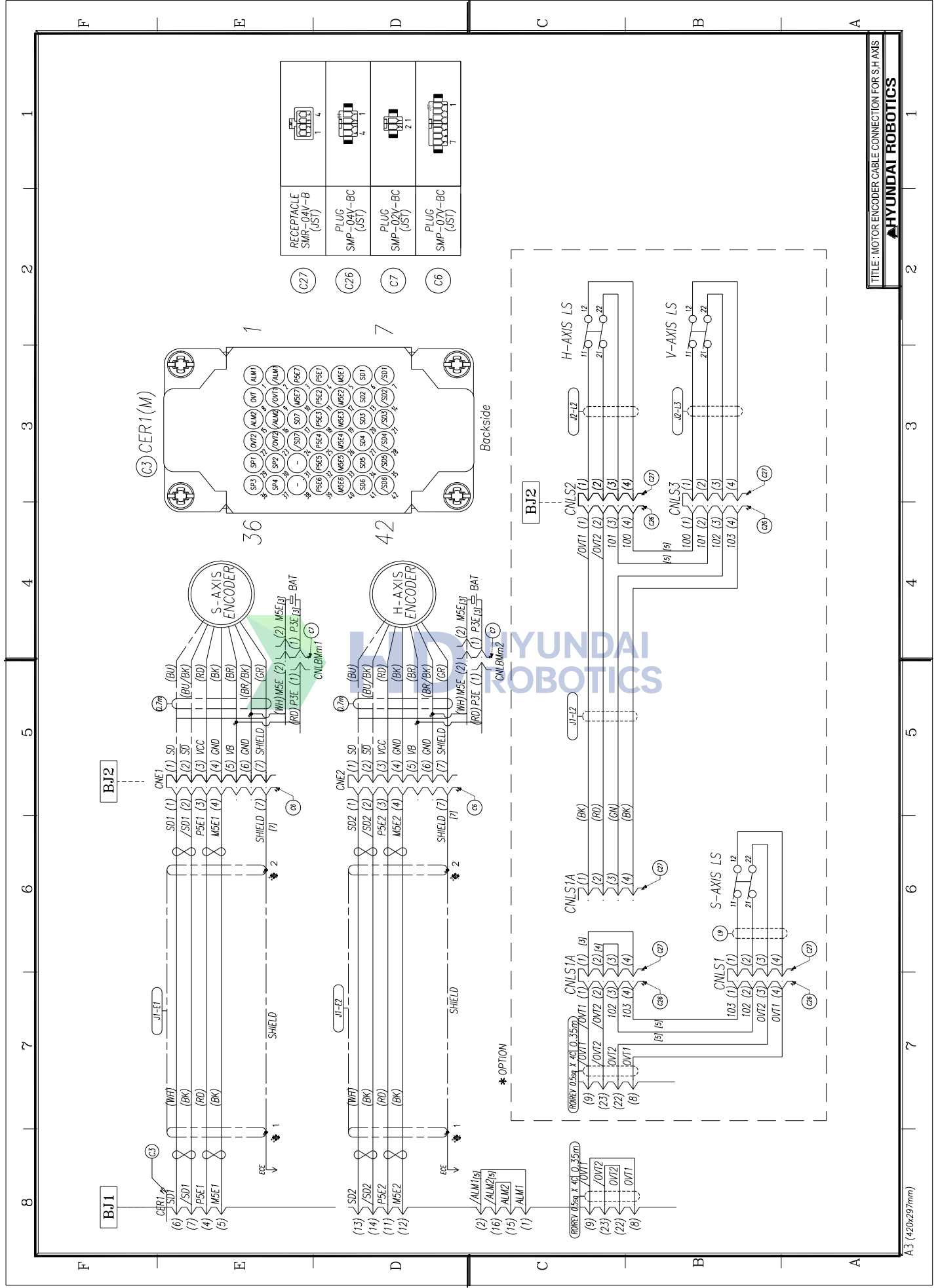


HX300 Series Internal wiring diagram

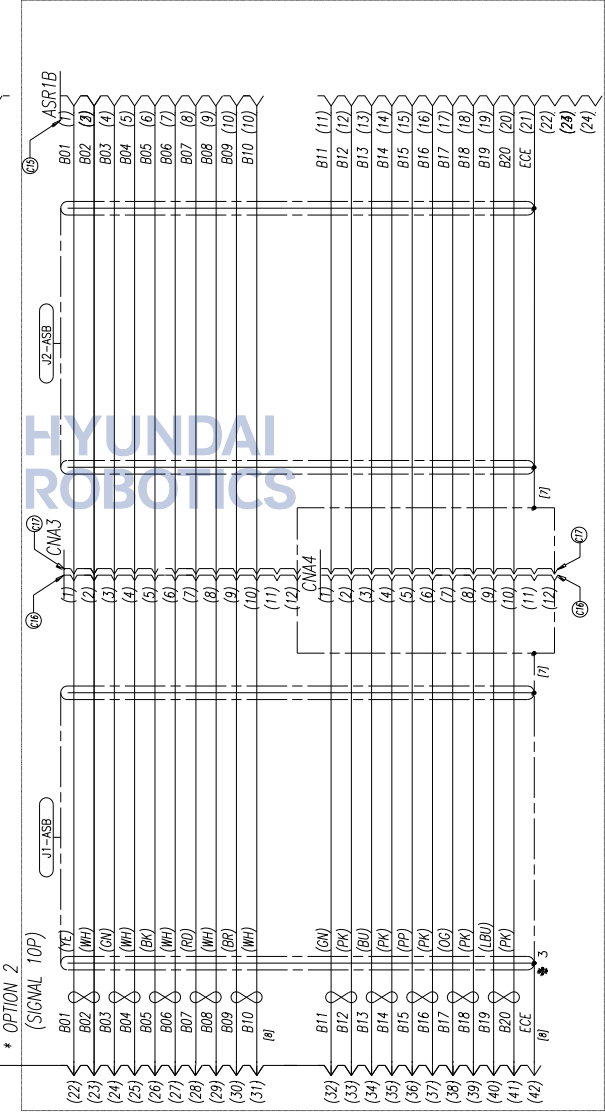
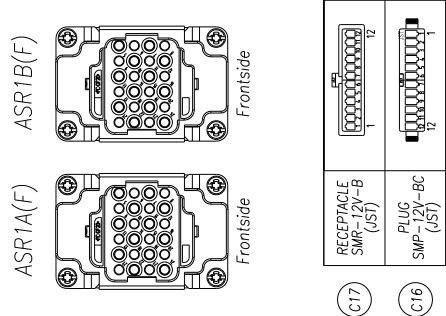
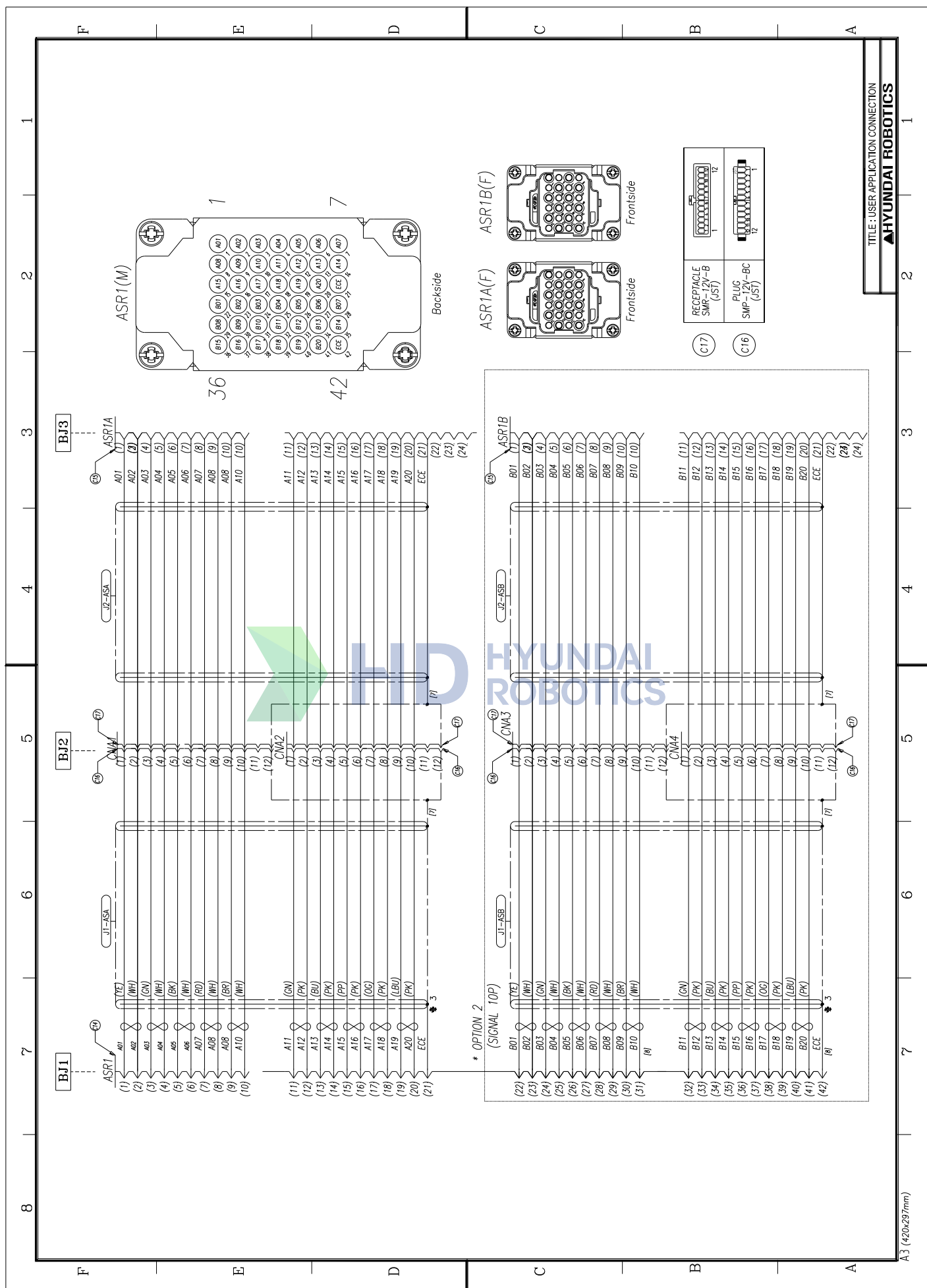
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3	MOTOR POWER CABLE CONNECTION FOR R2,B,R1 AXIS
4	MOTOR ENCODER CABLE CONNECTION FOR S,H AXIS
5	MOTOR ENCODER CABLE CONNECTION FOR V,R2,B,R1 AXIS
6	USER APPLICATION CONNECTION
7	USER APPLICATION CONNECTION



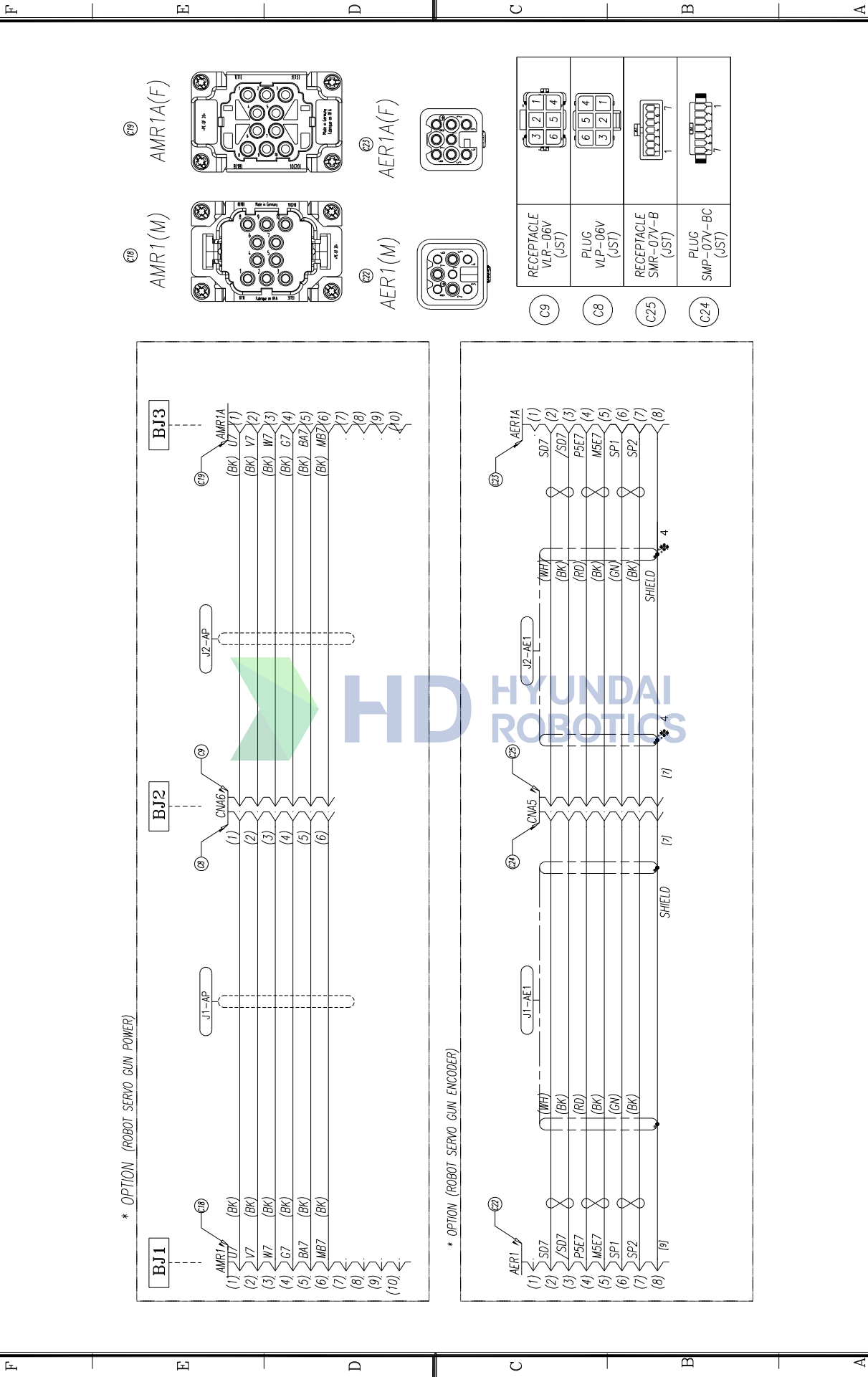








8 7 6 5 4 3 2 1



* OPTION (ROBOT SERVO GUN POWER)

* OPTION (ROBOT SERVO GUN ENCODER)

C9	RECEPTACLE VLR-06V (JST)	
C8	PLUG VLP-06V (JST)	
C25	RECEPTACLE SMR-07V-B (JST)	
C24	PLUG SMP-07V-BC (JST)	



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