Simple and friendly

Kawasaki

Kawasaki Robot
duAro

Safety Manual

Robot

Kawasaki Heavy Industries, Ltd.

90801－1009DEA

PREFACE

This manual describes precautions and rules for safety when using Kawasaki duAro robot, the dual-arm SCARA robot. Read and fully understand this manual and other related manuals including Instruction Manual, etc., and prepare the safety measures required for each procedure before initiating use of the robot.

The contents of this manual apply to only the Kawasaki duAro robot produced by Kawasaki.

1. This manual does not constitute a guarantee of the systems in which the robot is utilized. Accordingly, Kawasaki is not responsible for any accidents, damages, and/or problems relating to industrial property rights as a result of using the system.
2. It is recommended that all personnel assigned for activation of operation, teaching, maintenance or inspection of the robot attend the necessary education/training course(s) prepared by Kawasaki, before assuming their responsibilities.
3. Kawasaki reserves the right to change, revise, or update this manual without prior notice.
4. This manual may not, in whole or in part, be reprinted or copied without the prior written consent of Kawasaki.
5. Store this manual with care and keep it available for use at any time. If the robot is reinstalled or moved to a different site or sold off to a different user, attach this manual to the robot without fail. In the event the manual is lost or damaged severely, contact Kawasaki.

SYMBOLS

The items that require special attention in this manual are designated with the following symbols.

Ensure proper and safe operation of the robot and prevent physical injury or property damage by complying with the safety matters given in the boxes with these symbols.

⚠ DANGER

Failure to comply with indicated matters can result in imminent injury or death.

⚠ WARNING

Failure to comply with indicated matters may possibly lead to injury or death.

⚠ CAUTION

Failure to comply with indicated matters may lead to physical injury and/or mechanical damage.

[**NOTE**]

Denotes precautions regarding robot specification, handling, teaching, operation and maintenance.

CONTENTS

1.0 SAFETY PRECAUTIONS

Compliance with laws and risk assessment

Work in coexistence with human is possible by using the duAro. When introducing the robot, conduct risk assessment as recommended in ISO12100 “Safety of machinery – General principles for design – Risk assessment and risk reduction”* [1] as is the case with general mechanical equipment, and take appropriate safety measures.

As stated in national and local laws and legislation*[2], safety provision is the most essential concern when using industrial systems that include robots. In the event of physical injury or property damage as a result of robot use, the plant that utilizes the robot will be held liable. Accordingly, it is important to fully understand all statutes and standards regarding health and safety in addition to this manual and its related texts, and to comply with their contents.

*1: JIS B 9700: “Safety of machinery – General principles for design – Risk assessment and risk reduction”
*2: Labour standards bureau, Ministry of Health, Labour and Welfare: “Guidelines for the comprehensive safety standards of machinery”

Product application

Do not use the robot for applications with high risk to human life and properties including the applications described below. Kawasaki is not responsible for any accidents, damages, and/or problems as a result of using the robot for those applications, including non-performance of the main obligation, defect liability, quality assurance responsibility, tort liability and product liability, but these are not limited.

1. Nuclear power plant, thermal power plant, hydraulic power plant
2. Railway, aviation, vehicle facility and other traffic systems
3. All equipment related to medical care and life support
4. Facilities for recreation
5. Incineration equipment and fuel system
6. Handling facility of nuclear substance, harmful substance and chemical substance
7. Mining and excavation
8. Other applications which require high safety equivalent to the above 1. to 7.

Precautions for use

The manual describes general safety matters of the robot and is not intended to describe safety for any individual system in which it is used. Accordingly, when using the robot, prepare the “safety measures appropriate for each system and working environment” in accordance with the result of risk assessment and comply with them.

Assignment and transfer of duAro

If the robot is assigned or transferred to a different site, attach this manual to the robot without fail so that the recipient does not experience difficulties in using the robot.

2.0 GENERAL SAFETY PRECAUTIONS

⚠ DANGER

The manual focuses exclusively on safety matters for the main body of the robot and is not intended to describe safety for the whole system or any individual system in which it is used. Accordingly, read and understand fully all pertinent laws, regulations, user manuals and related materials and prepare the safety measures suitable for each system and working environment before initiating use of the robot.

The following are general precautions relating to safe use of the robot.

1. Conduct teaching and maintenance in compliance with all national/international laws, local legislation and industrial codes and standards.
2. Participate in the special education and training course to conduct teaching/maintenance work of the robot.
3. It is recommended that all personnel assigned to install, operate, teach, inspect, maintain, and troubleshoot the robot attend the Kawasaki prepared education/training course(s) that would be pertinent to each employee's specific job. Please contact the Kawasaki office listed on the rear cover for information on education/training course(s).
4. Before installing, operating, teaching, inspecting, maintaining, and troubleshooting the robot, customers are expected to fully understand this Safety Manual and other related manuals/documents, and to comply with safety precautions.
5. Plant operating personnel should prepare and comply with safety regulations based on established guidelines for ensuring work safety.
6. Plant operating personnel should appoint a full-time operator and safety supervisor who are responsible for creating a safety regulation system that administers all safety related issues, including safety education.
7. In order to prevent accidents from occurring with the robot, the supervisor should provide the following safeguarding measures according to the conditions at each robot's installation.
   (1) Install an emergency stop device in an easily accessible area within reach of the operator. No emergency stop switch is provided on tablet, therefore, provide the emergency stop device within tablet operator's reach.
   (2) Display the robot status clearly so that the current condition of the robot can be seen by everybody.
   (3) Prepare safety procedures in accordance with the configuration of the actual line and peripheral equipment.

(4) The administrator should provide relevant training to all personnel assigned to operate, teach, inspect, maintain, and repair the system. Also, personnel should be given the necessary education to gain proficiency in their work procedures including all measures for ensuring safety.

8. Always confirm that conditions are safe prior to initializing or restarting the robot, and remove any obstacles within its motion range. If it is necessary to stop motion instantly, press EMERGENCY STOP switch. Never stop the robot with any part of your body or tools because it is very dangerous.
9. Do not operate the robot over its specified capacities (load, speed, motion range, environment, etc.).
10. The robot can move in a wide area with variety of motion patterns. Take precautions to prevent the hand from throwing the workpiece held in its grasp and to prevent the robot arm from impacting or crushing the peripheral equipment.
11. Verify the position and function of all EMERGENCY STOP switches. Never perform conversions on work cell or system which render the safety related devices, be they mechanical or electrical, useless by jumper out, etc.
12. Properly install all safety devices to prevent danger, and perform the periodic maintenance as scheduled.
13. For safety, design and install the interlock for electro-mechanical interfacing between system devices to be failsafe – a standard used in device construction that ensures: 1) personnel are protected from harm if any one part of the device malfunctions, and 2) that the system automatically assumes a safe state after an error.
14. Robot arm is labeled with a warning sign, so comply with its stated safety instructions and protect the label against damage and soiling. In the event the label becomes illegible, consult Kawasaki.
15. Never step on robot arm or cart. The following accidents may happen and cause not only part deformation/property damage but physical injury.
    (1) Personnel lose their footing,
    (2) If casters are unlocked, duAro moves, falls, etc.
16. Avoid wearing loose fit clothing, ties, scarves, and accessory. Additionally, wear the specified protective gear, safety eyeglasses, helmet, and safety shoes required for each working environment and condition.
17. If any personnel observe unsafe working conditions, report them immediately to the supervisor or plant safety coordinator so that corrective actions can be taken.

3.0 SAFETY AT EACH WORK PROCESS

Robot work processes are divided into the following seven categories, and the safety considerations to be taken for each category is explained below.

1. Safety at Installation and Connection
2. Safety before Activation of Robot
3. Safety at Robot Activation
4. Safety during Teaching
5. Safety during Automatic Operation
6. Safety during Troubleshooting
7. Safety during Inspection and Maintenance

3.1 SAFETY AT INSTALLATION AND CONNECTION

For all operations at installation and connection, strictly comply with the following items.

1. Read and understand fully all manuals, specifications and related documents provided by Kawasaki before operation. In addition, understand thoroughly all procedures for operation, teaching and maintenance. Also, make sure that all the necessary measures for safety are installed and fully functioning.
2. When lifting the robot, follow the Instruction Manual.

⚠ DANGER

1. **Only personnel qualified in crane operation must be permitted to move/transport the robot.**
2. **Never go near or under a hoisted robot during transport.**
3. **Never get on the robot, touch or support them manually during transport.**

3. When transporting the robot, remove all the connected harnesses so that cables, etc. do not get caught on other devices.
4. Before transporting robot, remove unnecessary objects and clear the path up to the installation site.
5. Do not transport the robot by a forklift, the robot cannot be transported by a forklift structurally.
6. Do not connect external power cable to controller while the external power switch to the installation site is ON. Failure to do so is extremely dangerous and may cause electric shock. Confirm that external power supply is turned OFF before connecting external power

cable. Also, display signs indicating clearly power-off, inspection/maintenance, repair in progress, and fix the external power switch with a lock (lockout) or place a tag (tagout) to prevent personnel from accidentally turning ON the power.

7. When transporting the robot manually using the cart, hold the handle firmly and move the robot paying attention for the robot not to fall, while confirming the condition of the installation site. Transport the robot on the smooth flat surface by the cart.
8. Horizontal axes of the robot are not equipped with brakes, so fix the horizontal axes with a fixing jig, etc. before the transportation.
9. For the connection of external power, comply with the specified conditions, including power-supply voltage, frequency and size of wire used. In addition, connect the external power to the robot with the external power switch OFF.
10. Before installing the robot, make sure that robot arm is not over a head.
11. Robot may fall depending on the robot motion or motion speed, so fix the robot on the floor or peripheral equipment, etc.
12. When mounting an option inside the cart, execute operations with the power from external power and peripheral equipment OFF.

3.2 SAFETY BEFORE ACTIVATION OF ROBOT

For all operations before activation of robot, strictly comply with the following items.

1. Read and understand fully all manuals, specifications and related documents provided by Kawasaki before operation. In addition, understand thoroughly all procedures for operation, teaching and maintenance. Also, make sure that all the necessary measures for safety are installed and fully functioning.
2. Make sure that no operator, packing material, jig, or obstacles of any kind are within the robot's motion range.
3. Before turning the robot power ON, ensure that installation is performed according to Instruction Manual, a separate volume.
4. Never turn ON the external power without connecting signal harness and motor harness connected to the tip wrist unit. It may result in an accident such as electric shock.

⚠ DANGER

Never turn ON the external power unless connection of the wrist unit completes. An accident such as electric shock may happen.

5. Before activating the robot, ensure that the cart is fixed firmly.

6. For all utilities (water, air and gas, etc.), a system for monitoring of the rated values must be established.
7. If a great deal of garbage, metal particles, fine particles, etc. are expected to have some influence on the robot, then the robot must be protected with appropriate covers, etc.

CAUTION

For safety during installation and connection, comprehend and comply with the contents of Instruction Manual, a separate volume.

3.3 SAFETY AT ROBOT ACTIVATION

To activate the robot, the controller power is turned ON first, followed by motor power (Press the start button.). For this operation, strictly comply with the following items.

DANGER

Before activation of robot, confirm that all EMERGENCY STOP switches function normally.

1. Read and understand fully all manuals, specifications and related documents provided by Kawasaki before operation. In addition, understand thoroughly all procedures for operation, teaching and maintenance. Also, make sure that all the necessary measures for safety are installed and fully functioning.
2. Check all of switches, displays, signal names and functions necessary for robot operation.
3. Never enter the motion range until it is confirmed that all safeguarding devices function normally when safeguarding devices are installed.
4. If robot is activated in a system where several operators work, determine a starting signal that all operators and related personnel know and recognize as the robot activation signal.
5. Before turning the motor power ON (before pressing the start button), make sure no person or obstacle remains around the robot.
6. Do not short-circuit and disable the emergency stop and safety device.
7. When turning ON motor power, keep your hand on the EMERGENCY STOP switch so that motor power can be turned OFF immediately.
8. Before activation of robot, reconfirm that the following conditions are satisfied.
   (1) Before turning the motor power ON (before pressing the start button)
      1) Be sure that the installation of robot is adequate and stable.
      2) Be sure that connection of the external power to the robot is adequate and specifications (power voltage, frequency, etc.) are satisfied.

3) Be sure that the connection with utilities (water, air and gas, etc.) is adequate and conforms to the specification.
4) Be sure that connections (wiring and piping) to peripheral equipment are correct.
5) Be sure to check that the related parts have no problems after the robot is stopped by mechanical stopper.
6) Be sure that the safety measures are adopted as needed; safeguarding devices and interlock are installed.
7) Be sure that the safeguarding devices and interlock function normally for 6) above.
8) Be sure that environmental conditions (temperature, humidity, light, noise, dust, etc.) are satisfied.

(2) After turning the motor power ON (after pressing the start button)
1) Be sure that the hold/run and teach/repeat mode selectors function normally.
2) Be sure that the robot axes move normally within the restricted range and speed.
3) Be sure that the emergency stop circuit and safety devices on robot and peripheral equipment, etc. function normally during robot operation in teach/repeat modes.
4) Be sure that the collision detection function works normally. (Refer to the Instruction Manual, a separate volume, for details of setting and checking methods.)
5) Be sure warning sign labels are not damaged/soiled, and the function works when a signal tower is mounted. In addition, all safety devices including warning lamps and safeguarding devices function normally.
6) Be sure that the external power source including controller power, air, etc. can be cut OFF.
7) Be sure that the teaching and repeat functions are normal.
8) Be sure that the robot axes move properly and can perform the work at safety speed.
9) Be sure that the robot can operate properly in automatic mode and can perform the planned operation at the specified speed and load.

3.4 SAFETY DURING TEACHING

For teaching, strictly comply with the following items.

DANGER

Before teaching, confirm that all EMERGENCY STOP switches function normally.

1. Read and understand fully all manuals, specifications and related documents provided by Kawasaki before operation. In addition, understand thoroughly all procedures for operation, teaching and maintenance. Also, make sure that all the necessary measures for safety are installed and fully functioning.

2. Before activation of robot, be sure to confirm that all the safeguarding devices function normally.
3. Teach with two persons, an operator and an observer. Assign a person as “Work supervisor” beforehand and perform teaching after mutually confirming signal for “work starting”, etc.
4. Disable automatic operation functions while the operator is within the motion range. If the robot makes any abnormal motion, immediately press the EMERGENCY STOP switch and evacuate on a planned path of retreat.
5. Install the E-STOP switch for the observer as needed. The observer must watch teaching work and press the E-STOP switch immediately in case robot motion becomes abnormal. Moreover, the operator and observer must be personnel who have completed the special education and training course.
6. Display a sign, “Teaching in progress” to prevent personnel from accidentally operating any robot during teaching operations.
7. After completing the teaching, before confirming the taught data and motion, move all people away from the motion range, and then perform the confirmation outside the motion range after making sure no person or obstacle remains inside the motion range or around the robot. Also, at this time, operate the robot at low speed until it is confirmed normal.
8. If reactivating the robot after an emergency stop, conduct the operation outside the motion range. Confirm conditions are safe before reactivating without fail, and make sure no person or obstacle remains inside the safeguarding devices or around the robot.
9. During teaching, be sure to confirm the motion range of the robot, and do not approach the robot carelessly or go under the robot arm. Especially when the workpiece is grasped, be careful because it may suddenly fall by mistaken operation.
10. For safety, the maximum speed for the robot in teach or check mode is limited to 250 mm/s (safety operation speed). However, set the check speed as low as possible just after starting teaching, when personnel are verifying the teaching data in check mode, after error occurs, etc.
11. During teaching, both operator and observer must always watch out for abnormal motion and possible hit/pinch points in and around the robot. Also, ensure a safe passage for the operator in the event immediate evacuation is required.

3.5 SAFETY DURING AUTOMATIC OPERATION

Because taught programs are played back at high speed, strictly comply with the following items.

⚠ DANGER

Before automatic operation, confirm that all EMERGENCY STOP switches function normally.

1. Read and understand fully all manuals, specifications and related documents provided by Kawasaki before operation. In addition, understand thoroughly all procedures for operation, teaching and maintenance. Also, make sure that all the necessary measures for safety are installed and fully functioning.
2. Never enter or let any part of your body inside the set low speed motion area during automatic operation. Also, make sure no person or obstacle remains inside the low speed motion area prior to running the robot.
3. When the robot is waiting for a timer or external signal input during automatic operation, it may appear stopped. However, do not approach the robot because it will restart motion to the next step once the timer has elapsed or the external input signal is input.
4. It is extremely dangerous if the workpiece is grasped insufficiently during automatic operation because it may be thrown by the robot's motion. Be sure that the workpiece is grasped firmly and workpiece, etc. does not drop in robot's normal motion. When workpiece is handled by mechanisms such as pneumatic hands, electromagnet, etc., employ a failsafe system to prevent the workpiece from being ejected if the mechanism's drive is cut OFF. If there is even the smallest possibility that the workpiece may fly outward at times of error, install a protective net, etc.
5. Post signs to prevent personnel from entering areas except the low speed motion area, indicating the area as an off-limit area. Also, post signs indicating that automatic operation is in progress and entry to the work cell is off limits. Furthermore, ensure a safe passage for the operator in the event immediate evacuation is required.
6. If an error causes the robot to stop during automatic operation, check the displayed error message, follow the appropriate recovery procedures, and reactivate the robot.
7. Be sure to confirm that safe working conditions are satisfied before reactivating the robot after recovery procedures, and make sure no person, jig, peripheral equipment, obstacle, etc. remains inside the safeguarding devices or around the robot.

3.6 SAFETY DURING TROUBLESHOOTING

To work on troubleshooting, strictly comply with the following items, and report all details to Kawasaki, including robot model, controller model, machine number, any options, etc. when trouble occurs.

⚠ DANGER

Before troubleshooting work, confirm that all EMERGENCY STOP switches function normally.

1. Read and understand fully all manuals, specifications and related documents provided by Kawasaki before operation. In addition, understand thoroughly all procedures for operation, teaching and maintenance. Also, make sure that all the necessary measures for safety are installed and fully functioning.
2. Before entering the motion range, make sure all necessary safety measures are prepared and functioning well.
3. Before entering the motion range, turn OFF controller power up to the external power switch. Display signs indicating clearly power-off, troubleshooting in progress, and fix the external power switch with a lock (lockout) or place a tag (tagout) to prevent personnel from accidentally turning ON the power.
4. Troubleshooting duties are limited to personnel who have completed special training/education for the installed robot or for an equivalent model.
5. Before troubleshooting work, ensure enough space around the robot so that there is no interference with peripheral equipment. Take measures so that the peripheral equipment will not make any sudden motion.
6. Disable automatic operation functions when operator is inside the motion range. If the robot makes any abnormal motion, press EMERGENCY STOP switch immediately, and evacuate on a planned path of retreat.
7. In addition to the EMERGENCY STOP switch for the operator, install another E-STOP switch for the observer outside the motion range, in a place where the robot's entire motion range can be watched. If the robot moves abnormally during troubleshooting, the observer must press the E-STOP switch immediately. After an E-Stop, reset and reactivate robot operations from outside the motion range. Moreover, the operator and observer must be personnel who have completed the special education and training course.
8. During operation, both operator and observer always watch out for abnormal motion and possible hit/pinch points in and around the robot.
9. Use only Kawasaki approved parts during replacement.

10. When replacing parts inside the controller, turn OFF controller power without fail. Be careful of the remaining voltage after turning OFF the controller power. Wait at least five minutes after turning OFF the controller power, and then, confirm that the remaining voltage is 0 V before starting operations. Also, be careful not to touch any parts that may be hot.
11. When air or water is supplied, shut OFF the supply source, release all the pressure lines and make sure that no pressure remains before proceeding with troubleshooting.
12. Because the type of printed boards or power block, etc. differs per model, use lighting of 300 lux (preferably 500 lux) or more to avoid mistakes when reading the type or replacing defective parts.

3.7 SAFETY DURING INSPECTION AND MAINTENANCE

In order to prevent troubles, clean, inspect and maintain the robot or replace parts in strict compliance with the following items.

⚠ DANGER

Before inspection and maintenance work, confirm that all EMERGENCY STOP switches function normally.

1. Read and understand fully all manuals, specifications and related documents provided by Kawasaki before operation. In addition, understand thoroughly all procedures for operation, teaching and maintenance. Also, make sure that all the necessary measures for safety are installed and fully functioning.
2. Before inspection and maintenance work, remove unnecessary objects and clear the path up to the installation site.
3. Inspection and maintenance duties are limited to personnel who have completed special training/education for the installed robot or for an equivalent model.
4. Before inspection and maintenance work, ensure enough space around the robot so that there is no interference with peripheral equipment. Take measures so that the peripheral equipment will not make any sudden motion.
5. Before entering the motion range, turn OFF controller power for the entire line or for the robot on which work is to be performed, also turned OFF power up to the external power switch. Display signs indicating clearly power-off, inspection/maintenance, repair in progress, and fix the external power switch with a lock (lockout) or place a tag (tagout) to prevent personnel from accidentally turning ON the power. If the entire line cannot be stopped, install temporary fences, etc. between the subject robot and any adjacent robots in close proximity.

6. When performing the inspection and maintenance of interlock circuit, without fail turn OFF all power sources connected with the interlock circuit to ensure safety. During this work, never enter the motion range.

DANGER

After completing the inspection and maintenance, be sure to confirm that the safeguarding devices (EMERGENCY STOP switch, etc.), peripheral equipment or safety devices such as interlock circuit function normally.

7. In addition to the EMERGENCY STOP switch for the operator, install another E-STOP switch for the observer outside the motion range, in a place where the robot's entire motion range can be watched. If the robot moves abnormally during observation of maintenance/inspection, the observer must press E-STOP switch immediately. After an E-Stop, reset and reactivate robot operations from outside the motion range. Moreover, the operator and observer must be personnel who have completed the special education and training course.
8. Disable automatic operation functions while the operator is within the motion range. If the robot makes any abnormal motion, immediately press the EMERGENCY STOP switch and evacuate on a planned path of retreat.
9. During inspection/maintenance, both operator and observer must always watch out for abnormal motion and possible hit/pinch points in and around the robot. Also, ensure a safe passage for the operator in the event immediate evacuation is required.
10. Use only Kawasaki approved parts during replacement. Also, in inspection/maintenance, move the robot in teach mode and at the lowest possible speed without fail. At this time, refer to 3.4 Safety during Teaching together.
11. Many semiconductors are used in the printed boards. Because the semiconductor devices are sensitive to static electricity, there is the threat of electrostatic discharge damage if touched directly by hand. When holding the printed board, be sure to hold the edges of it without touching any semiconductor parts. If board parts must be touched, discharge one's body in advance and confirm without fail that one's person is electrically neutral.
12. When placing printed boards in the cart etc. directly, there is the threat of electrostatic discharge damage to the semiconductor devices. Be sure to place the board on antistatic mat or sheet, or put it into the antistatic bag.
13. When replacing parts inside the controller, turn OFF controller power without fail. Be careful of the remaining voltage after turning OFF the controller power. Wait at least five minutes after turning OFF the controller power, and then, confirm that the remaining voltage is 0 V before starting operations. Also, be careful not to touch any parts that may be hot.

14. Support the axis firmly with a suitable device before removing servo motor from JT3 (vertical axis). Removing the motor will disable the braking mechanism for that axis, and without proper support, the axis will fall due to its weight. In addition, when removing the motor of the robot, wait at least five minutes after the controller power OFF and make sure that the motor and surroundings are not hot.
15. If robot must maintain the same pose before and after the work, record the robot pose data before replacing the parts.
16. At the start of the replacement process, when removing printed boards or cables, check and record their position, connector No., installed condition, set data, etc. so that arrangements may be fully restored. The connector with lock mechanism must be surely locked after inserting. Also, never touch connector pins.
17. When the utilities (water, air and gas, etc.) are supplied, shut OFF the supply source and purge any remaining pressure from the lines before proceeding with inspection/maintenance.
18. Because the type of printed boards or power block, etc. differs per model, use lighting of 300 lux (preferably 500 lux) or more to avoid mistakes when reading the type or replacing defective parts.
19. After inspection/maintenance, confirm that all safeguarding devices function normally.
20. After inspection/maintenance, another qualified personnel, other than the operator, must check. If there is no abnormality, operate the robot again.
21. For daily check/periodic inspections, be sure to comply with the specified inspection time.
22. For the basic structure of the robot (arm and cart section), do not convert the robot without the consent of Kawasaki. If converted without prior approval, Kawasaki cannot assume any responsibility.
23. In the robot arm and controller, various batteries are used for backup of data. If used mistakenly these batteries may malfunction as well as ignite, overheat, explode, corrode, leak, etc., thus strictly comply with the following instructions.

⚠ DANGER

1. **Use only Kawasaki specified batteries.**
2. **Never re-charge or dismantle, convert and heat the batteries.**
3. **Never dump the batteries into water or fire.**
4. **Batteries with damaged surface may short out internally, and thus must never be used.**
5. **Never short out the plus and minus of the batteries with metallic material such as wire.**

CAUTION

Never dump old, depleted batteries with garbage that is disposed in incinerator, land-fill, dumping-ground, etc. When dumping the batteries, insulate with tape so as not to contact other metal and comply with local regulations and rules for battery disposal.

4.0 SAFETY FEATURES OF THE KAWASAKI ROBOT

Kawasaki duAro robots are equipped with the features below to safeguard personnel during operations. Use these features in addition to devising safety measures that are appropriate for each individual system.

1. All the Emergency Stop circuits are composed of hardwire logics.
2. Robot cart is equipped with mushroom-shaped push lock EMERGENCY STOP buttons. Also, a connecting port is provided on the bottom of the cart to install E-STOP buttons externally.
3. Speed and deviation of the robot are monitored by the controller, and if either value exceeds the threshold, an error is detected, and the robot stops.
4. For safety, the speed of the robot moved by using a tablet in teach or check mode is limited to 250 mm/s (safety operation speed).
5. Motion range of the robot is set to the maximum range (movable range) at shipping unless specified.
6. Z axis (vertical axis) of the robot is equipped with electromagnetic brake and the brake is applied to prevent the JT3 from dropping by its own weight even if the controller power is turned OFF. However, other axes than JT3 are not equipped with the brakes.
7. Low output motors whose rated output is less than 80 W are used for driving all axes of the robot.
8. Cushion is provided on the robot arm to absorb shock in collisions with personnel, etc.
9. The robot has a function which reduces speed depending on area monitoring result and a collision detection function to absorb shock in interference.
10. The robot has a function to prevent interference between robot arms in motion.

5.0 RESIDUAL RISKS OF ROBOT

Kawasaki duAro robot has various safety characteristics listed in the previous chapter but risks described below still remain, so conduct risk assessment without fail when using the robot and take appropriate measures.

1. During installation and connection

Falling

・When transporting the robot manually using a caster of the cart, transport the robot on the smooth flat surface. It may trip over something and fall.

・Robot may fall depending on the robot motion or motion speed, so fix the robot on the floor or peripheral equipment, etc.

Pinching

・Horizontal axes of the robot are not equipped with brakes, so fix the horizontal axes with a fixing jig, etc. before the transportation to avoid possible physical injury or damage due to the contact or pinching.

Electric shock

・Do not turn ON the controller power with robot cover and connector of robot harness, etc. being removed to avoid possible electric shock.

Collision

・Before installing the robot, make sure that robot arm is not over a head to avoid possible physical injury due to collision with the robot or damage to the robot.

Tools to be used

・Do not mount a pointed tool at the tip of robot. Consider providing cushioning for protection when a tool to be used has a pointed part.

2. During teaching

Pinching/Collision

・There is a possibility of physical injury by being caught between joint parts of robot arm or arms of robots, or damage to robot and equipment when operating the robot directly while grasping the robot. In addition, be careful not to be caught between robot and peripheral equipment when operating.

Moreover, pay attention not only to the pose of the arm which is being taught but also to that which is not operated.

3. During operation

Pinching/Collision

・Robot has a collision detection function, however, there is a possibility of physical injury or damage to robot and equipment because the impact of collision or pinching during high-speed operations is high.

・As collision risk treatment measures, max operation speed is limited at factory setting. It is possible to remove the limit by changing the setting but to do so, it is required to conduct risk assessment and take appropriate measures that can avoid the contact with human in high speed operation.

4. During repair, maintenance and inspection

Pinching

・There is a possibility of physical injury by being caught between joint parts of robot arm or arms of robots, or damage to robot and equipment when moving the arm by grasping the robot. Pay attention not only to the pose of the arm being moved but also to that which is not moved.

Electric shock

・Do not turn ON the controller power with robot cover and connector of robot harness, etc. being removed to avoid possible electric shock.

High temperature

・Surrounding area of servo motor and controller may be hot after robot motion, and there is a possibility of getting burned. Check the temperature of the parts using a contact thermometer, etc. before operations.

5. At disposal

Environmental load

・Never dispose of depleted batteries with garbage that is disposed of in an incinerator, land-fill, dumping-ground, etc. When disposing of batteries, insulate with tape so as not to contact other metal. Comply with local regulations and rules for battery disposal.

Kawasaki Robot

duAro

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