Kawasaki Robotics

ASTORINO

Safety Manual

03.2025-6(EN)

Preface

This manual describes the safety of the 6-axis robot “astorino"
and the associated "astorino" software.

The ASTORINO is a learning robot specially developed for educational institutions. Pupils and students can use the ASTORINO to learn robot-assisted automation of industrial processes in practice.

This is an original documents and is not translated.

1. The "astorino" software included with the ASTORINO is licensed for use with this robot only and may not be used, copied or distributed in any other environment.
2. Kawasaki shall not be liable for any accidents, damages, and/or problems caused by improper use of the ASTORINO robot.
3. Kawasaki reserves the right to change, revise, or update this manual without prior notice.
4. This manual may not be reprinted or copied in whole or in part without prior written permission from Kawasaki.
5. Keep this manual in a safe place and within easy reach so that it can be used at any time. If the manual is lost or seriously damaged, contact Kawasaki.

Symbols

Items that require special attention in this manual are marked with the following symbols.

Ensure proper operation of the robot and prevent injury or property damage by following the safety instructions in the boxes with these symbols.

⚠ WARNING

Failure to observe the specified contents could possibly result in injury or, in the worst case, death.

[**ATTENTION**]

Identifies precautions regarding robot specifications, handling, teaching, operation, and maintenance.

⚠ WARNING

1. **The accuracy and effectiveness of the diagrams, procedures and explanations in this manual cannot be confirmed with absolute certainty. Should any unexplained problems occur, contact Kawasaki Robotics GmbH at the above address.**
2. **To ensure that all work is performed safely, read and understand this manual. In addition, refer to all applicable laws, regulations, and related materials, as well as the safety statements described in each chapter. Prepare appropriate safety measures and procedures for actual work.**

Paraphrases

The following formatting rules are used in this manual:

- For a particular keystroke, the respective key is enclosed in angle brackets, e.g. <F1> or <Enter>.
- For the button of a dialog box or the toolbar, the button name is enclosed in square brackets, e.g. [Ok] or [Reset].
- Selectable fields are marked with a square box ☐.
  If selected a check mark is shown inside the symbol ☑.

List of contents

1 Nomenclature in this manual

The author of the manual tries to use generally valid terminology while achieving the greatest possible logical sense. Unfortunately, it must be noted that the terminology is reversed depending on the point of view when considering one and the same topic. Also it is to be stated that in the course of the computer and software history terminologies developed in different way. One will find therefore in a modern manual no terminologies, which always satisfy 100% each expert opinion.

2 Overview of ASTORINO

The ASTORINO is a 6-axis learning robot developed specifically for educational institutions such as schools and universities. The robot design is based to be 3D printed with PET-G filament. Damaged parts can be reproduced by the user using a compatible 3D printer.

Programming and control of the robot is done by the "astorino" software.

The latest software version and 3D files can be downloaded from the KAWASAKI ROBOTICS FTP server:

https://ftp.kawasakirobot.de/Software/Astorino/

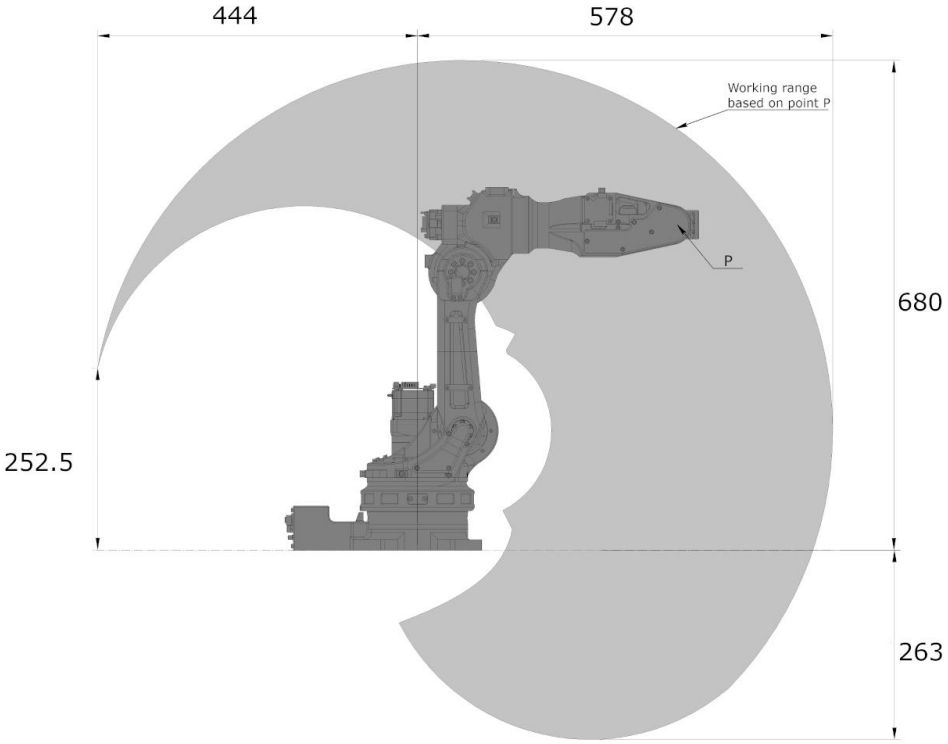
Just like Kawasaki’s industrial Robots the ASTORINO is programmed using AS language. Providing transferable programing skills from the classroom to real industrial applications.

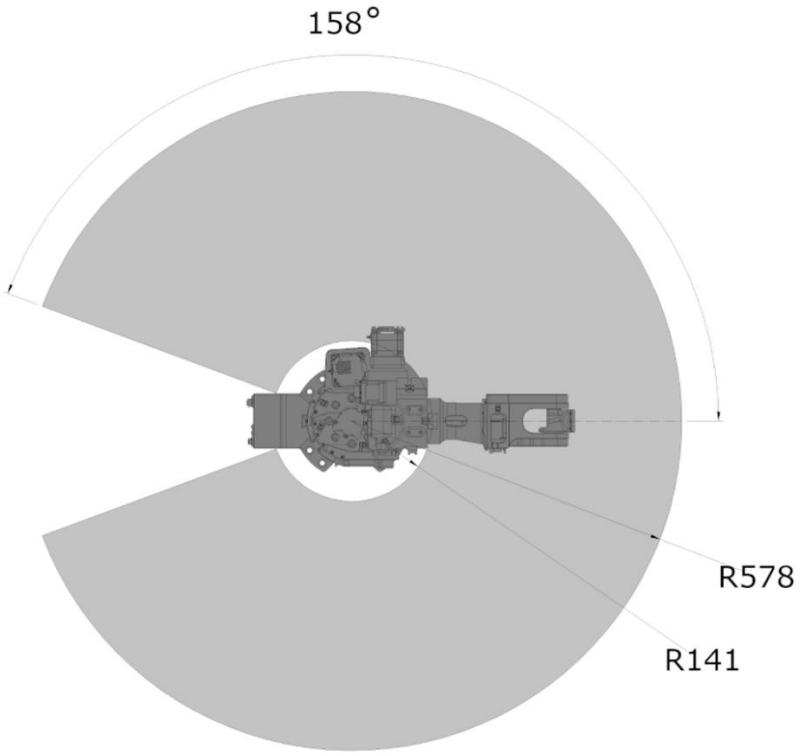
3 Technical specifications

Characteristics		ASTORINO
Type		6-axis robot
Max. lifting capacity		1 kg
Number of axes		6
Max. range		578 mm
Repeatability		±0.2 mm
Motion range	Axis 1 (JT1)	±158°
	Axis 2 (JT2)	-90°÷127°
	Axis 3 (JT3)	0°÷168°
	Axis 4 (JT4)	±240°
	Axis 5 (JT5)	±120°
	Axis 6 (JT6)	±360°
Max. single axis speed	Axis 1 (JT1)	38°/s
	Axis 2 (JT2)	26°/s
	Axis 3 (JT3)	26°/s
	Axis 4 (JT4)	67.5°/s
	Axis 5 (JT5)	67.5°/s
	Axis 6 (JT6)	128.5°/s
Allowable moment	Axis 4 (JT4)	6.2 Nm
	Axis 5 (JT5)	1.45 Nm
	Axis 6 (JT6)	1.1 Nm
Working environment	Temperature	15–35°C
	Humidity	35–60%
Controller		Teensy 4.1
Inputs/Outputs		8/8 (PNP 8 mA, NPN 15 mA)
		2/2 (24V PNP on the JT3)
Max. current consumption		144 W
Power supply		100–240 V, 50–60 Hz
Max. emitted acoustic pres.		< 73 dB(A)
Weight		11 kg
Mounting position		Floor
Material		PET-G
Colour		Black
Communication		MODBUS TCP, TCP/IP, UDP, SERIAL
Collision detection		Accelerometer
Power loss safety		Brakes on JT2 and JT3
Options	24V I/O-module	8 × Inputs / Outputs
	7^{th} axis	Linear Track
	Vision system	OpenMV
	Belt tracking	Max. 2 Encoder

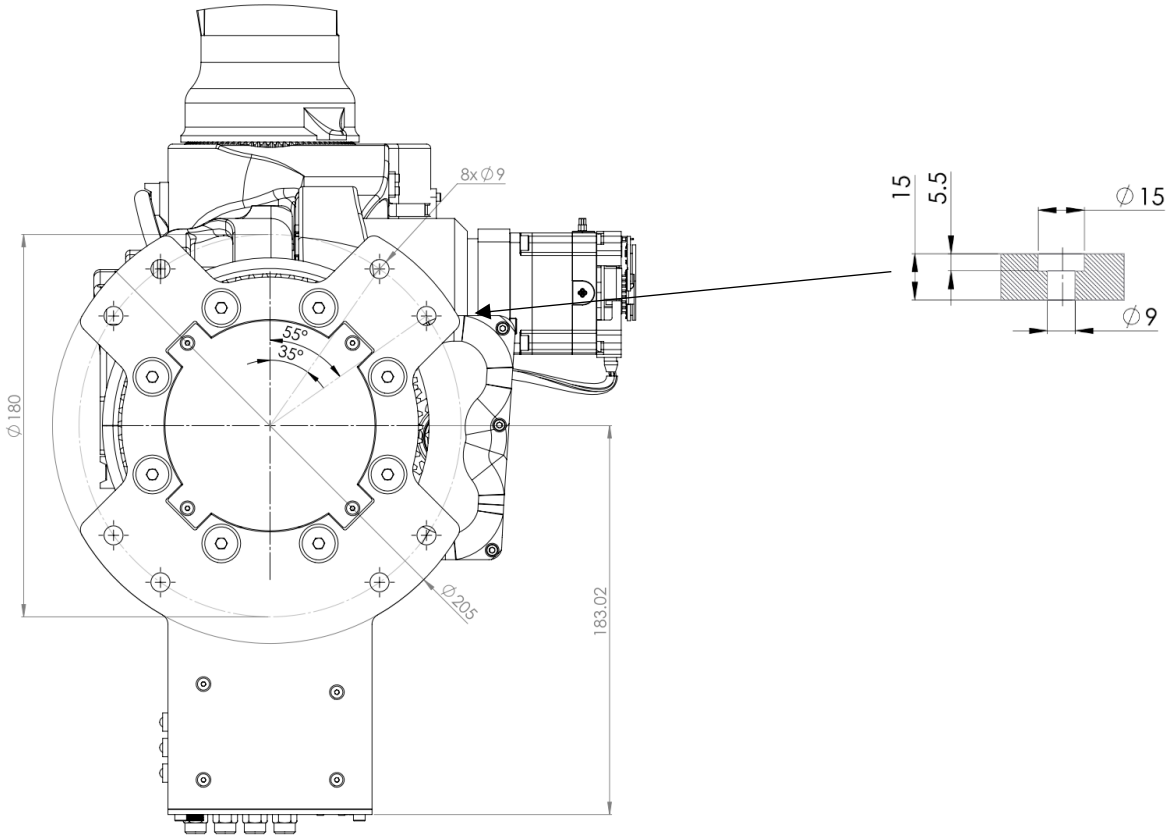
4 Range of motion

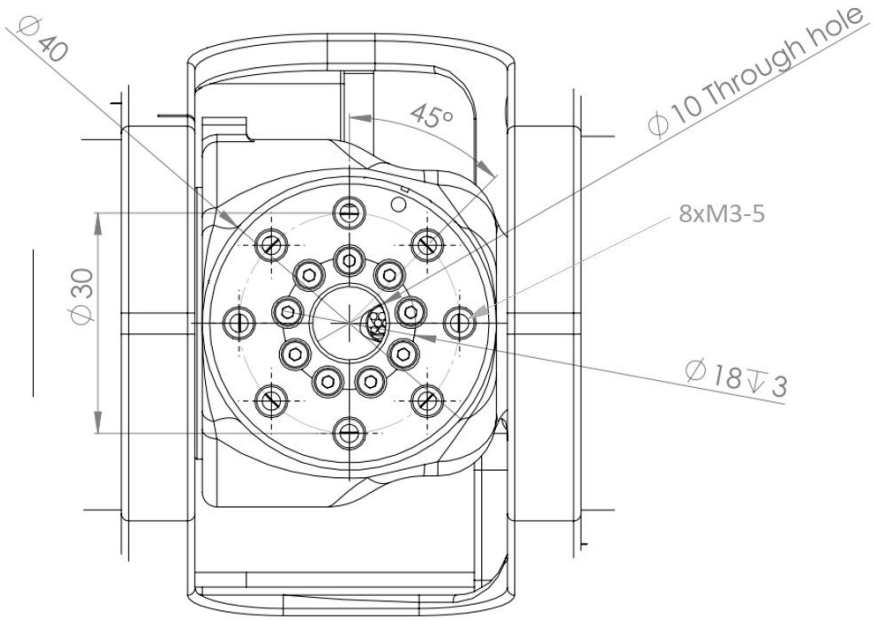
The motion ranges shown in the figures below are based on point P. For specifications of robot arms not shown in this manual, see the specification sheets, delivered separately.





5 Mounting dimensions





6 Intended operation

The astorino robots are designed to move and position small loads or objects. astorino robots are meant to be educational robots, working in controlled environment of laboratories as training machines.

According to the Machine Directive 2006/42/EC astorino robot is a partly completed machinery.

Furthermore, if are intended to be incorporated into or assembled with other machinery or other incomplete machinery or equipment in order to form a machine along with them in accordance with Machinery Directive 2006/42/EC.

A risk assessment in accordance with the safety regulations applicable in your country is necessary prior to each installation and use of the robot. Be sure to follow the safety instructions in this manual.

Astorino robot is intended for educational, and research and development purposes, i.e.:

- learning robotics,
- research and development in robotics,
- simulation and prototyping of complete industrial scenarios such as “Pick & Place” (take an object to move it), “Pick & Pack” (take an object to insert it into a packaging) etc.
- hardware application: connect and control the robot with sensors and external actuators in order to simulate an application, while respecting the conditions defined in this instruction manual,

The operations below do not comply with the uses set by Kawasaki Robotics and Astor. They include:

- use as a children’s toy,
- use for industrial tasks;
- use for handling inappropriate objects (with unsuitable grippers, objects whose mass is greater than the maximum authorized load),
- use that exceeds the stated specifications,

Any use of the robot and its ecosystem that does not comply with the uses initially intended by Kawasaki Robotics and Astor must be expressly authorized by Kawasaki Robotics and Astor.

7 Recommended age of students

Astorino was designed to be used in technical schools, high schools/college and universities. Recommended minimal age of student therefore is 16 years old. Youngs at lower age might find it difficult to use and program the robot safely.

8 Declaration of incorporation

DECLARATION OF INCORPORATION OF PARTLY COMPLETED MACHINERY

Astor Sp. z o.o.
Ul. Smoleńsk 29, 31-112 Kraków
Declares with full responsibility that the product:

ASTORINO robot

Serials numbers: B002-001 to B002-150

is intended to be incorporated into machinery or to be assembled with other machinery to constitute machinery covered by:

Machinery Directive 2006/42/EC
ANENEX I: 1.1.2(a), 1.1.2(b), 1.1.2(c), 1.2.1, 1.2.2, 1.2.3, 1.2.4, 1.2.5, 1.2.6, 1.3.1, 1.3.2, 1.3.3, 1.3.4, 1.3.7, 1.5.1, 1.5.6, 1.5.7, 1.6.1, 1.6.2, 1.7.1, 1.7.3, 1.7.4
ANNEX II, Part 1, sector B

Low Voltage Directive 2014/35/EU relating to electrical equipment supplied voltage below 1000V

EMC Directive 2014/30/EU relating to electromagnetic compatibility

the following standards have been applied:

EN ISO 12100:2010	Machine safety - General design principles - Risk assessment and risk reduction
EN ISO 13849-1:2023 **EN 60204-1:2018,** **EN ISO 4414:2010** **EN ISO 14120:2015**	Safety of machinery — Safety-related parts of control systems Safety of machinery - Electrical equipment of machines - Part 1: General requirements Pneumatic fluid power — General rules and safety requirements for systems and their components Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards
EN 61000-4-4:2012 **EN IEC 61000-4-6:2023** **EN IEC 61000-4-3:2020** **EN 61000-4-5:2014/A1:2017** **EN IEC 61000-4-11:2020** **EN 61000-4-8:2010** **EN IEC 55014-1:2021**	Part 6-1: Generic standards - Immunity standard for residential, commercial and light-industrial environments Electromagnetic compatibility (EMC) - Part 4-6 Electromagnetic compatibility (EMC) - Part 4-3 Electromagnetic compatibility (EMC) - Part 4-5 Electromagnetic compatibility (EMC) - Part 4-11 Electromagnetic compatibility (EMC) - Part 4-8 Electromagnetic compatibility - Requirements for household appliances, electric tools and similar apparatus - Part 1: Emission

the following standards have been partly applied

PN-EN ISO 10218-1:2011
5.1, 5.2.1, 5.2.2, 5.2.3, 5.2.4, 5.2.5, 5.2.7, 5.3.2, 5.3.3, 5.3.4, 5.3.5, 5.5.1, 5.6.1, 5.6.2, 5.7.2, 5.8.1, 5.8.3, 5.11, 5.13, 5.14, 7.1, 7.2

Robots and equipment for robotics - Safety requirements - Part 1: Industrial robots (ISO 10218-1: 2011)

PN-EN ISO 10218-2:2011
4.1, 4.3, 4.4, 4.5, 5.1, 5.3.1, 5.3.4, 5.3.6, 5.3.7, 5.3.9, 5.3.10, 5.3.11, 5.5.3

Robots for work in an industrial environment - Safety requirements - Part 2: Robotic system and integration (ISO 10218-2: 2011)

Authorized representative and Person authorized to compile the Technical Documentation:
ASTOR Sp. z o.o Smoleńsk 29, 31-112 Kraków
Marek Niewiadomski , Chief designer

…… (Place and Date)

…… Andrzej Garbacki, Vice-President, Robotization Director

9 Safety instructions

9.1 General information on safety

Always ensure the personal safety of users and others when operating the robot arm or starting the robot cell!

• In its basic version, the robot has no safety-related components for the robotic workstation. Such components may be required, depending on the target application. The basic version of the robot is provided with an emergency stop button.

• The robot controller includes a 24 V power supply that must be supplied with mains voltage (100/240 V). Please check the label on the power supply. Only qualified personnel can connect the power supply to the mains and put it into operation.

• Works carried out on the robot's electronic components should only be performed by qualified personnel. Check current guidelines for electrostatic discharges (ESD).

• Always disconnect the robot from the power supply (100/240 V) when working on the robot base (controller) or any electronic components connected to the robot controller.

• Hot-plugging is forbidden! It could lead to a permanent damage to motor modules. Do not install or remove any modules or plug/disconnect connectors (e.g. emergency stop button, DIO modules, motor connectors) while the power is on.

• The robot arm must be placed on a stable surface and bolted or otherwise secured.

• Use and store the robot only in a dry and clean place.

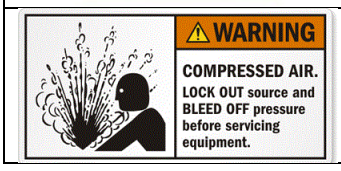
• Use the system only in a room temperature (15° to 32°C) — recommended.

- Please note that:
  - The robot can only be used under the proper technical conditions, for its intended uses, while taking into consideration potential hazards;
  - the robot must be used in accordance with the instructions in this manual;
  - Kawasaki Robotics or Astor is not liable for any modification made to the software or physical characteristics of the robot by the user.
  - We shall not be liable for any damage caused if it is used in a way that does not comply with the instructions given in this manual.

9.1.1 Signal words used

	GENERAL WARNING SIGNS They are used to alert the product user to potential hazards. All safety statements that follow this symbol must be followed in order to prevent possible damage
	SAFETY INSTRUCTIONS This pictogram indicates safety-relevant behaviour of the operator

9.1.2 Hazard warnings

	WARNING OF PINCH INJURIES There is a risk of crushing due to driven moving parts (connecting plates). If grippers or other electrical or pneumatic components are used as actuators, the relevant regulations of the manufacturer must be observed.
	WARNING OF ENTANGLEMENT HAZARD There is danger of hair and/or clothing being drawn in. Do not wear open hair, loose clothing or jewellery. There is a risk of injury from getting entangled or pulled in! Do not put any part of body to the places market by this sign
	WARNING OF HOT SURFACE There is danger of burn on when in contact with a skin
	WARNING OF DANGEROUS ELECTRICAL VOLTAGE The electrical drive should only be connected by qualified personnel. The applicable regulations must be observed and applied. The assembly device must be integrated in the local protective conductor system
	WARNING OF COMPRESSED AIR There is a risk of injury in case of improper release

9.1.3 Guidelines, laws and standards

The machine has been designed according to the guidelines and standards given in the declaration of incorporation

Failure to observe the safety instructions increases the risk of accidents as well as the risk of damage to the machine.

9.1.4 Validity

Significant changes to the articulated arm with drive units can lead to this declaration of incorporation becoming invalid. User can change 3D printed parts without making modifications to the 3D models.

9.1.5 User responsibility

Make sure that the aforementioned risk assessment is performed before each use of the robot. Make sure that the incorporation of the robot into other applications or ecosystems does not affect the robot's safety aspects.

Any modification of the equipment is prohibited. Robot stepper motor drivers parameters modification is prohibited.

Kawasaki Robotics and Astor disclaims all liability for any damage caused to and by the robot as a result of these modifications.

9.2 Safety instructions for personel

	Staff must be trained and be familiar with hazardous situations that arm can perform. Only trained persons must be employed on the machine! Trained personnel must fulfil the **Safety Questionnaire for Working with the Astorino Educational Robot** before use in education centres - Appendix I of this manual
	**Fire extinguishing**: Use a CARBON DIOXIDE (CO2) extinguisher in the event of a fire in astorino's system

9.3 Specific compoments

9.3.1 Safety devices

It is forbidden to remove or disable any safety device. If protective devices must be dismantled or disconnected for maintenance, repair or cleaning purposes, they must be re-installed and checked for efficacy after completion of the work.

	The machine must not be operated in automatic mode if the protective equipment is not working or disassembled! Robot cannot operate with more speed that 250mm/s therefore protective device other that Emergency stop button is not needed when working with safety clearance of at least 0.5m

9.3.2 Safety-relevant functions

The basic version of the robot control package does include safety-relevant functions:

- Emergency stop button,
- Collision detection functionality

Depending on the application, they may possibly have to be added.

The robot arm as delivered is an incomplete machine in the sense of Machine Directive 2006/42/EC and does not yet fulfil all basic health and safety requirements. Before being used for the first time, the robot arm must be subjected to an EC conformity assessment procedure by the user, possibly together with other (incomplete) machines. For safe use, additional protective measures are necessary.

9.4 Electrical

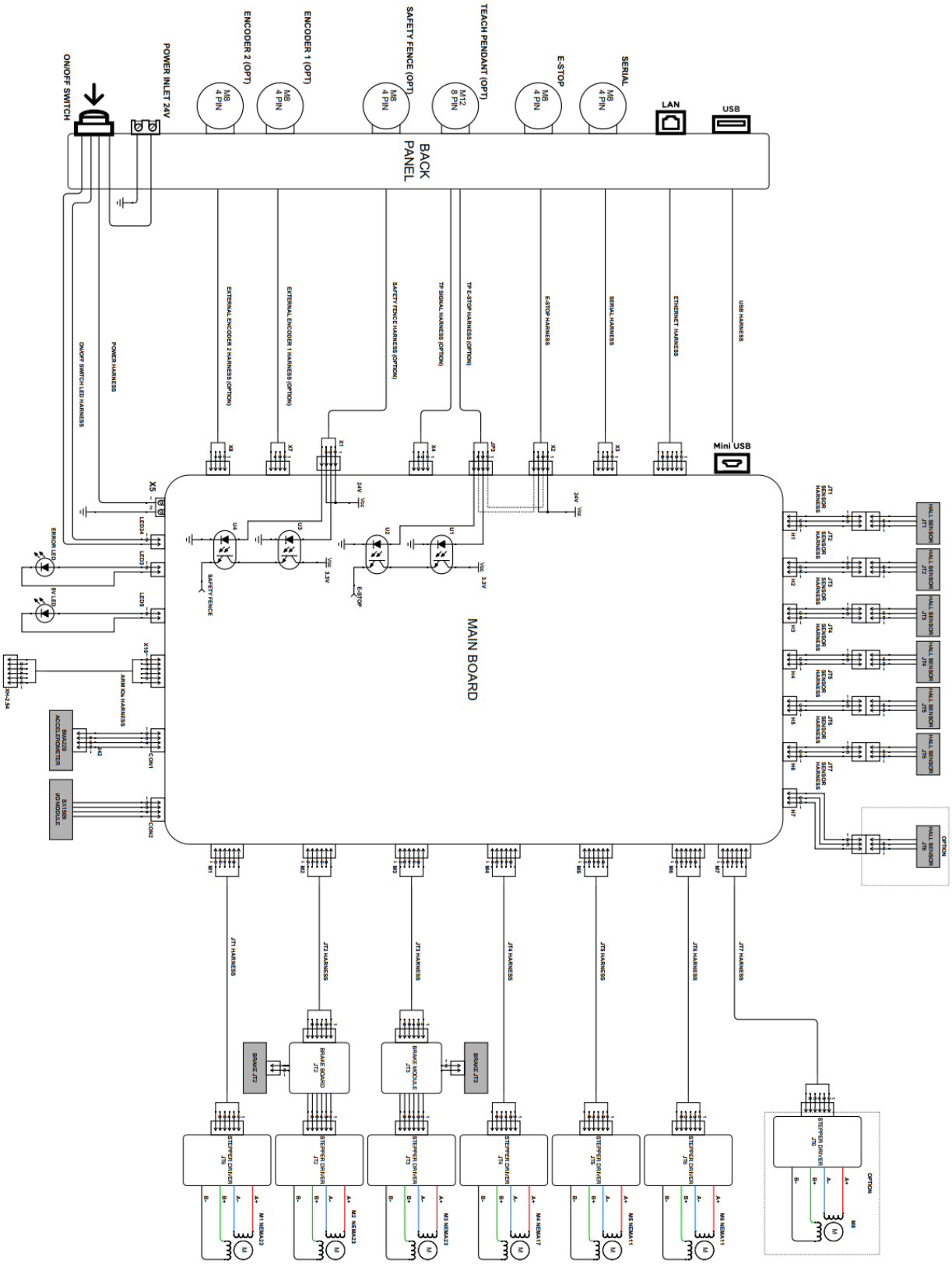
Work on robot electronics should only be done by qualified personnel. Check the directives for electro- static discharge (ESD). The robot control system includes a 24V mains adapter that itself need a mains voltage (120/240V). Please check the label on the mains adapter. Only qualified personnel are permitted to connect the mains adapter to the mains and start it up. Always disconnect the robot from the mains (120/240V) on the electronics that are connected to the robot control system. NO hot plugging! This can permanently damage the motor modules. Do not install or remove any modules (e.g emergency OFF switch, 24V DIO modules or external relays, motor connections) while they are switched on.

⚠ WARNING

Authorized personnel must be approved by Astor or Kawasaki Robotics company or their partners. Authorized personnel should also be trained how to deal with electronic equipment and must have all necessary legislations to work with electric equipment.

ASTORINO Safety Manual

Electrical architecture of astorino is showed below:



9.5 Specific life cycles of the product

9.5.1 Transport

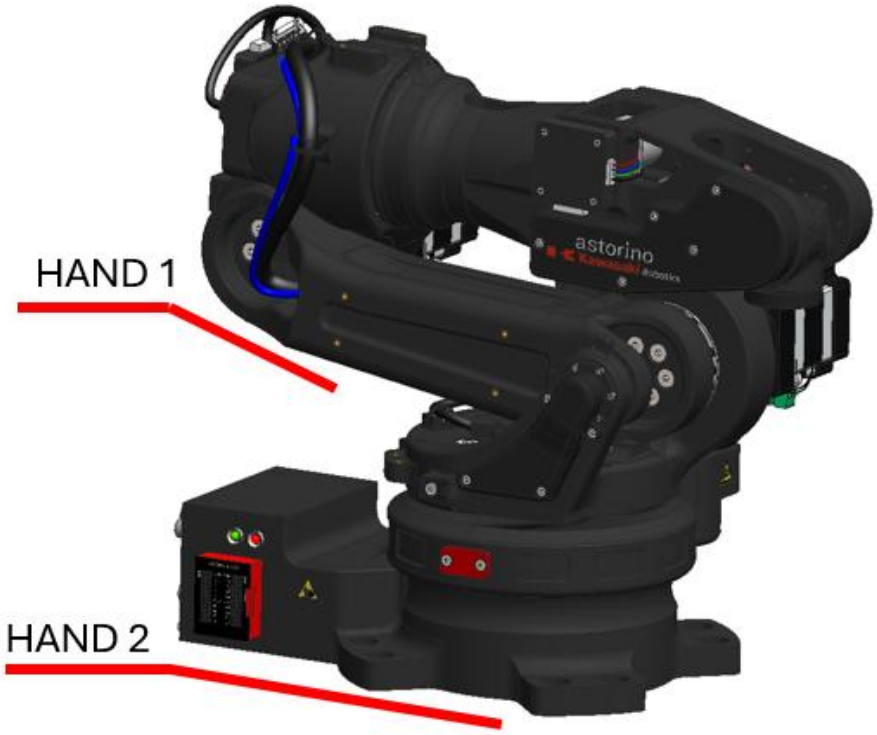
Transport of the machine should be done only in original box delivered with a robot. Transporting in any other way can damage the robot arm and will lead to invalidation of warranty.

Maintain good posture when handling the arm or arm cartons to avoid back injuries.

Make sure the robot is handled correctly so that the arm cannot fall during packing, loading, unloading or unpacking.

Handling areas are provided to facilitate the transport of the robot (see below). Make sure that the robot is handled correctly so that hands cannot get caught in the joints.

To do this, respect the handling zones specified below.



9.5.2 Installation/Robot environment/Cleaning

Only trained and appropriately qualified personnel, who are familiar with the structure of this type of machine, must be assigned to install and commission the machine. The robot arm must be placed on a robust surface and screwed on.

– Use and store the robot arm only in a dry, clean environment.

– Use the system only at room temperature (15° to +35°C).

– Do not cover stepper motor drivers and stepper motor t ensure a sufficient flow of air to cool them down.

	Cleaning work must only be carried out when the machine is at a standstill. Before starting the cleaning work, the machine must be switched off and isolated against accidental restart!

⚠ WARNING

Do not unplug pressure inlet without bleeding off pressure source first!

9.5.3 Dismantling

Decommissioning and disassembly of the machine must only be carried out by properly trained and qualified personnel.

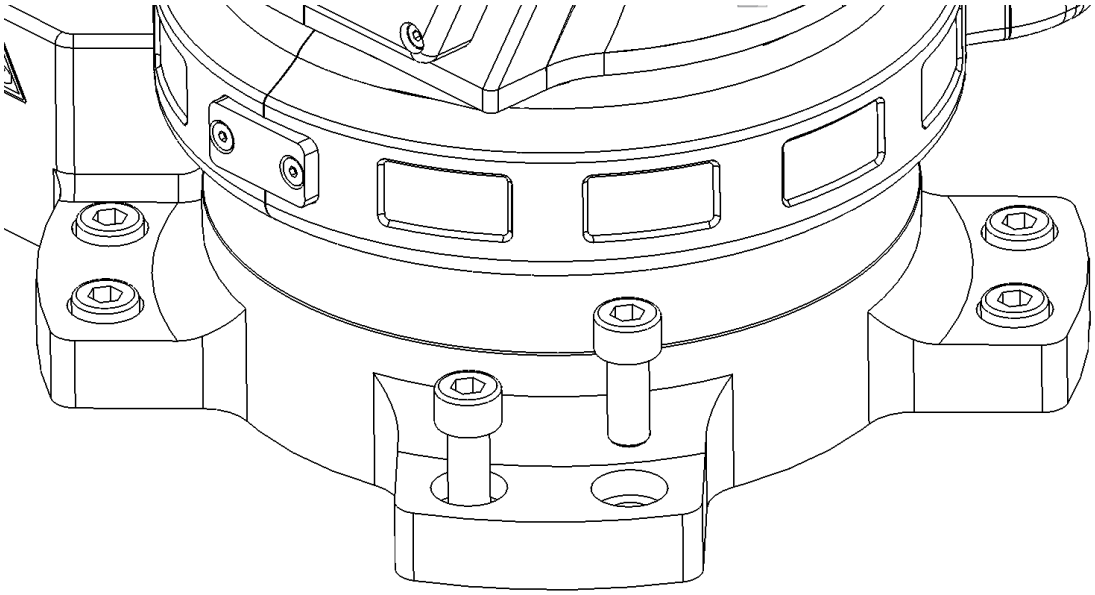
10 Installation instructions

The robot must be installed on rigid surface. Only the existing mounting holes must be used. The articulated arm must be able to move freely in all directions for zeroing of all joints.

The machine used in environment like laboratories, class rooms etc. is an INCOMPLETE MACHINE. In the delivered condition, it does not yet fulfil all safety requirements. It must only be operated after all the requirements of the Machinery Directive 2006/42/EC have been met.

	Make sure that the robot is properly installed on a firm surface with enough clearance to avoid shocks and collisions. (Refer to part 4. Range of motion of the robot). Cutting the power or activating the emergency stop button can cause the arm to drop a little. This drop is cushioned. Do not touch the robot when activating the emergency stop in order to avoid any collision. Be careful not to use the robot in unsuitable environments (e.g. outdoors). Do not put or install astorino in a damp environment or near water. Do not install or use astorino in hazardous environments (e.g. in a strong magnetic field, hazardous gas, fire or near flammable products) to prevent the hazards that can occur as a result of outdoor conditions. The robot and motors generate heat when they are running. Do not touch or handle the robot during operation or after prolonged use, the high temperature may cause pain. **When the astorino is activated, keep away from the areas labeled with the pinch warning sticker, to avoid any injury.**

Robot should be fastened to solid/rigid surface with 8x M8 screws. Please refer to 5 Mounting Dimension for installation holes pattern.



Default zero position of the Astorino robot arm.

10.1 Installation enviroment

- The installation site of the robot must fulfil all the following environmental conditions:
- When robot arm is installed on the floor, the levelness must be within ±5°.
- Be sure that the floor/stand has sufficient rigidity.
- Secure a flat place to prevent the base section from receiving undue force.
- Keep the ambient temperature during operation within the range of 15°C to 35°C
- Keep the relative humidity during operation within the range of 35% to 80%RH without dew condensation.
- The altitude of the installation place should be within the range of 0 m to 1000 m above mean sea level.
- The robot installing place should be free from dust, dirt, smoke, water, and other foreign matters.
- The robot installing place should be free from flammable or corrosive liquid or gas.
- The robot installing place should be free from excessively strong vibration. (0.5 G or less)
- The robot installing place should be free from electric noise interference.
- Place where power satisfying the specification is supplied.
- The robot installing place should be sufficiently larger than the motion range of robot arm.

Safety fence must enclose area larger than the maximum motion range of fully equipped robot arm (with tools) so it does not interfere with the surrounding objects.

10.2 Safety measures concerning robot installation

When astorino robot arm is not being installed in the laboratory or class room then place the robot arm within the safeguarding devices (guard, fence, equipment, etc. provided for preventing hazards) so that the robot arm is put off limits. Also, install an emergency stop device in an easily accessible area within reach of the operator to avoid unauthorized access to the arm.

Safety guarding zone (area surrounded by the safety fence) should be built so as to prevent the robot arm from jumping over or extending beyond the fence in the event of breakdown and/or error.

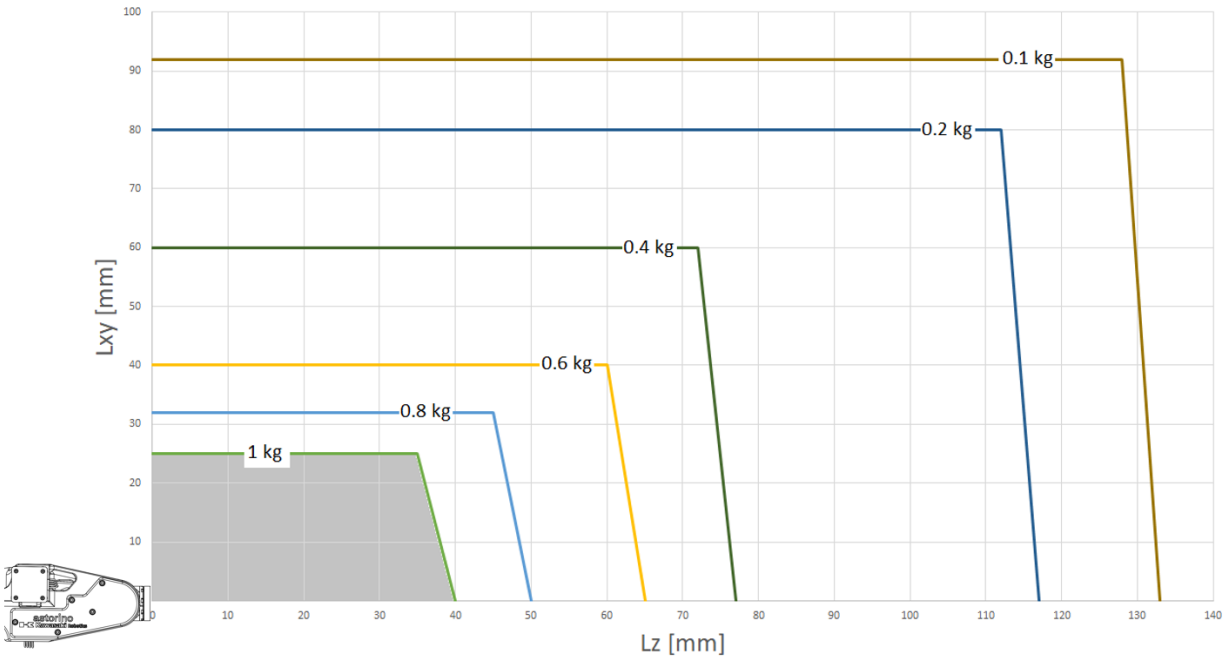
Minimize the number of doors on the safeguarding devices (preferably only one). The door should be equipped with a safety plug which must be removed manually in order to open/close the door. Then, set motor power to be turned OFF if plug is removed during automatic operation. Confirm that safety devices such as EMERGENCY STOP switch and safety plug function normally before entering the safeguarding devices.

Display the robot state clearly, such as: automatic mode, teaching, and emergency stop, etc. on the safeguarding devices so the current condition of the robot can be seen by everybody.

Limit the robot operating personnel to only those who have taken and completed the training course(s) authorized by Astor/Kawasaki.

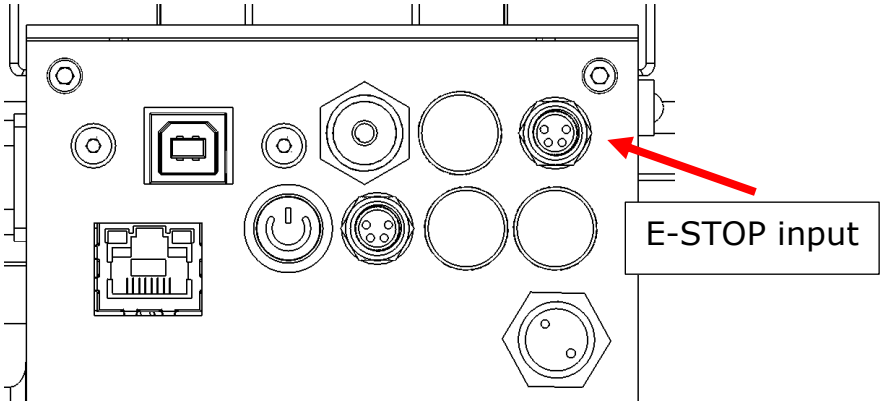
10.3 Maximum payload

Do not exceed rated payload of astorino robot, doing so might result in unpredictable behaviour for example drive oscillations.

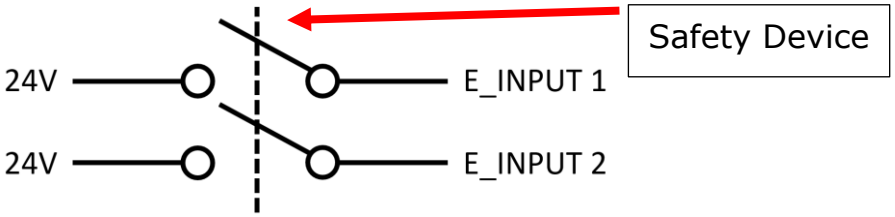


10.4 Emergency stop circuit

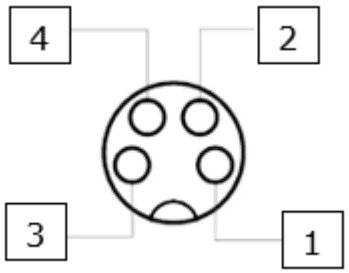
Robot is delivered with emergency stop button, but this button can be replaced by external safety system.



Emergency stop circuit is two channel, to connect external safety device follow listed below diagram.



10.5 Emergency stop plug



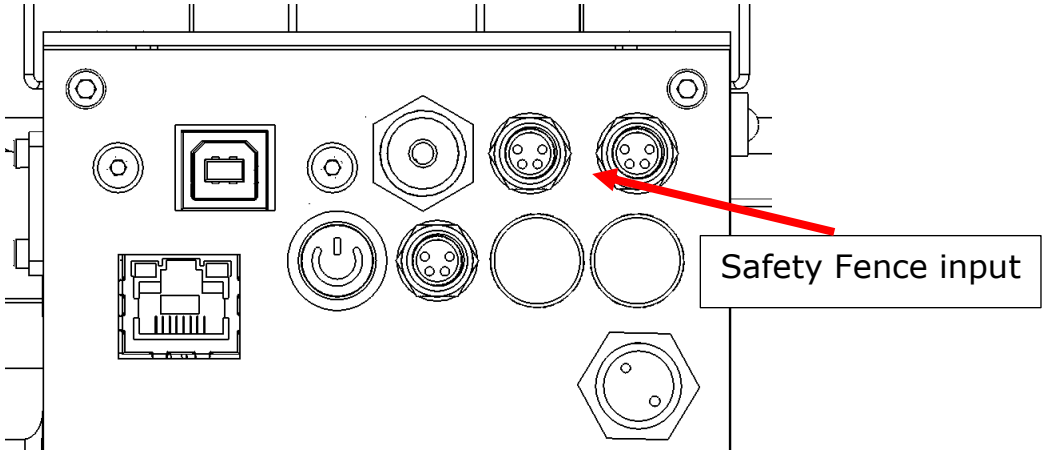
1	2	3	4
E_INPUT_1	24V	E_INPUT_2	24V

10.6 Safety Fence circuit (OPTION)

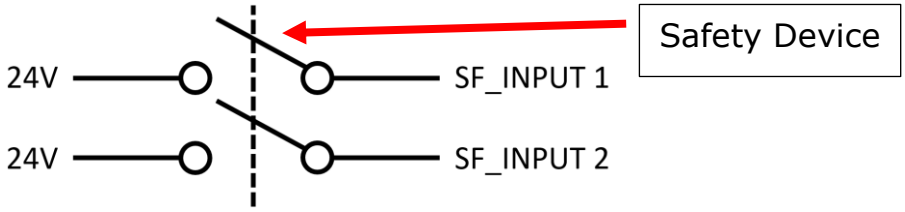
[ATTENTION]

Safety Fence emergency stop works only in Teach Mode!

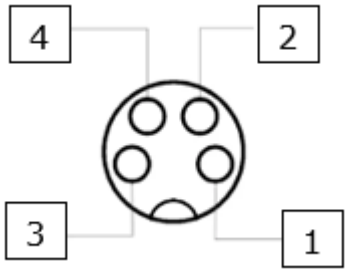
Robot is delivered with emergency stop button, but this button can be replaced by external safety system.



Emergency stop circuit is two channel, to connect external safety device follow listed below diagram.

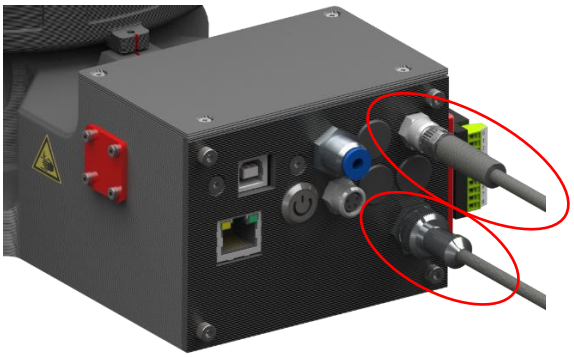
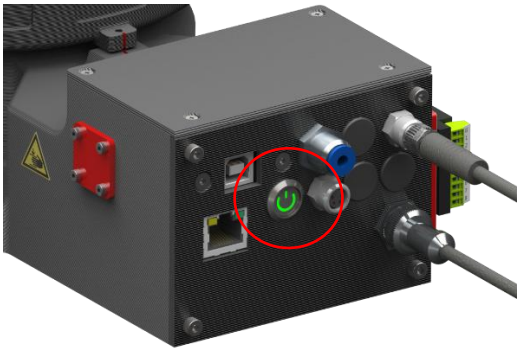


10.7 Safety Fence stop plug (OPTION)



1	2	3	4
SF_INPUT_1	24V	SF_INPUT_2	24V

10.8 Switching ON

Install the robot on a firm surface! Connect and screw the power supply connector and ESTOP connector to the robot.	
Turn on the power supply and press the on/off switch. The green light diode (LED) should light up. On the side of the robot arm leds should light UP. Green – 5V indicator Red – error indicator If there is no error on the robot red diode should turn off after few seconds.	

10.9 Connecting and moving the robot

	Please refer to Operation manual of the astorino robot.

11 Risk assessment

For each procedure of system setting, installation, teaching, operation, maintenance, disposal, etc., always make sure the instructions and specifications match the requirements of the purpose of robot use. Also, perform the adequate risk assessment without fail to reduce any avoidable risk.

Example of simple Risk Assessment is presented in the Appendix II of this Manual (**Risk Assessment for the Astorino Educational Robot and Additional Equipment**)

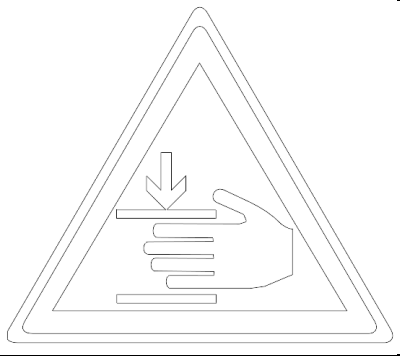
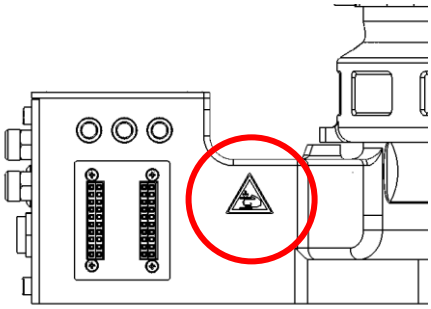
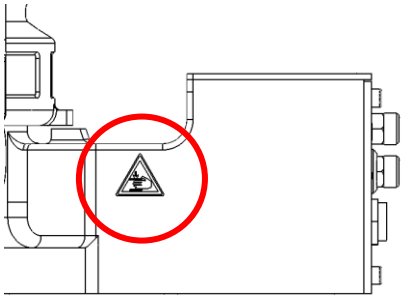
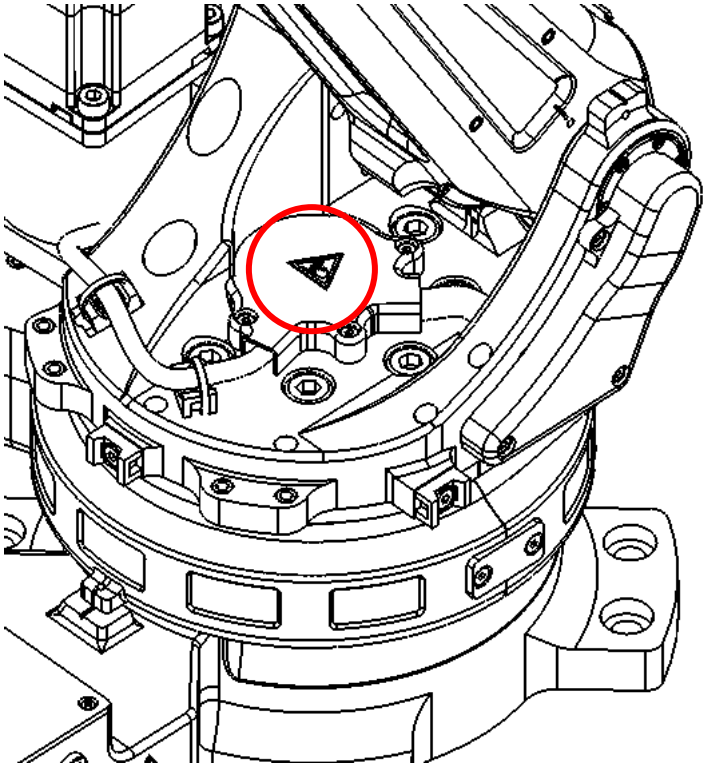
11.1 Safety features

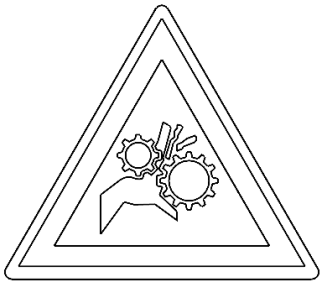
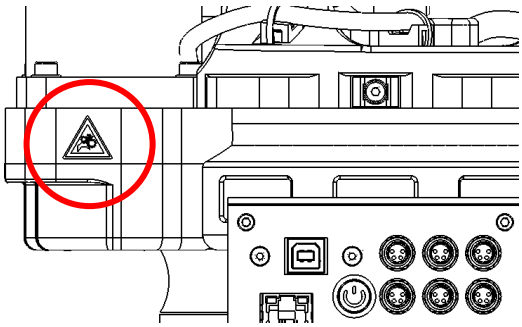
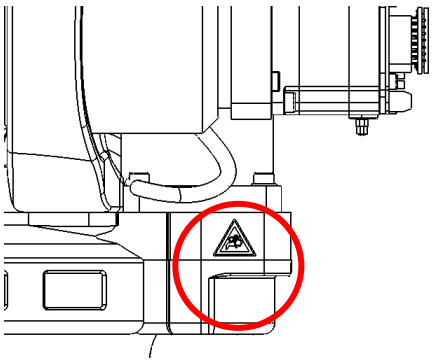
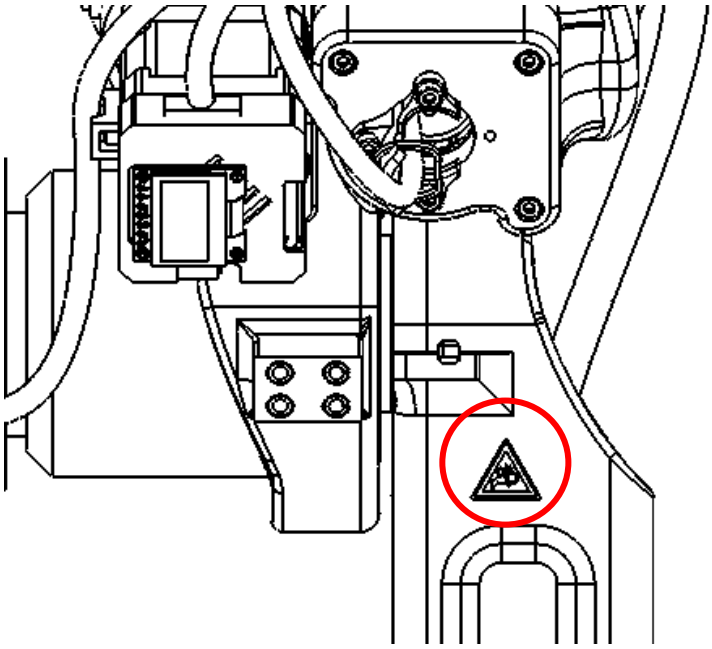
To safeguard the user, robot astorino is equipped with many safety features, including the following:

- All E-stops and Safety Fence inputs are hard-wired.
- All robot controllers are equipped with a redundant dual channel safety circuit. Both channels of the safety circuit must be closed to allow for robot operation in the teach and automatic playback modes.
- Velocities are limited to a maximum of 250 mm/s (10.0 in/s).
- JT1-JT3 are equipped with overtravel hardstops. Mechanical hardstops are capable of stopping the robot moving at full speed and with maximum payload.
- Collision detection unit is present.

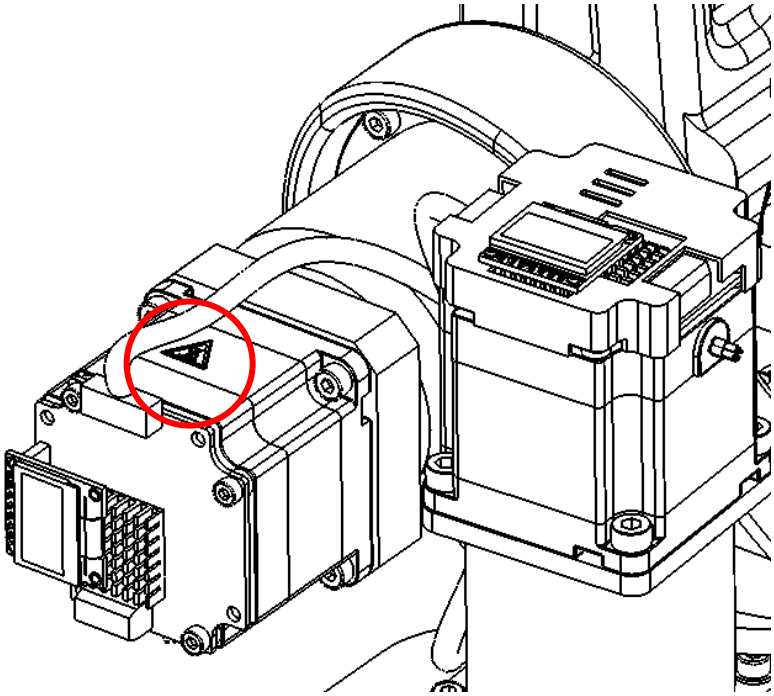
11.2 Residual risks

11.2.1 Warning labels

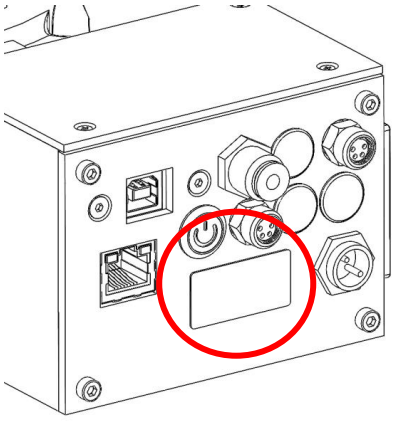
	**PINCH/HAND INJURY PLACES**
	
	

	**MOVING PARTS WITH RISK OF HAND INJURY**
	
	

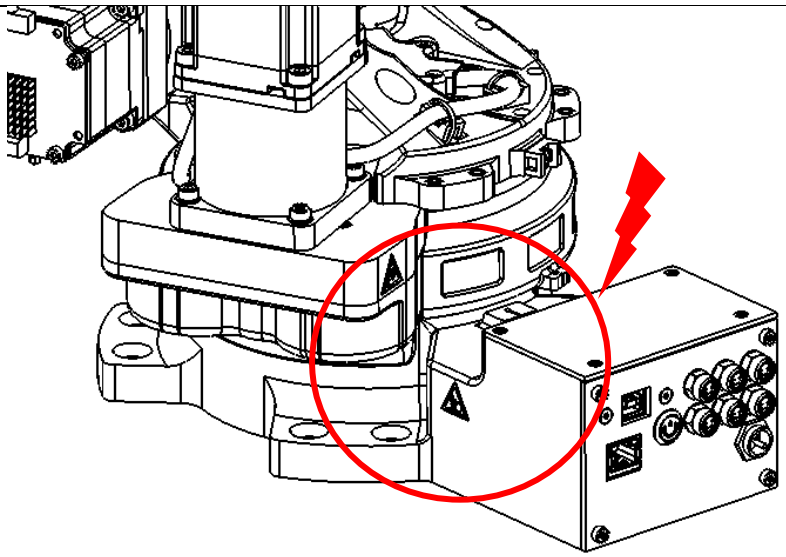
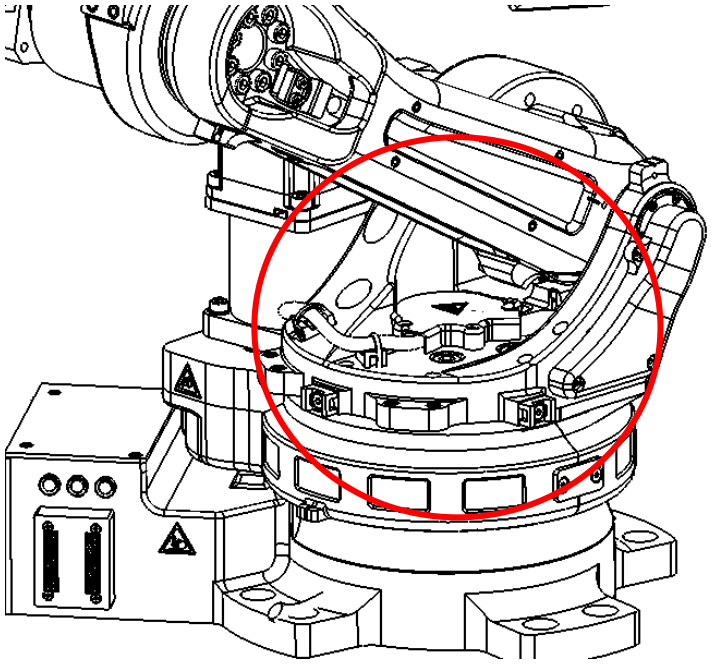
HOT SURFACE

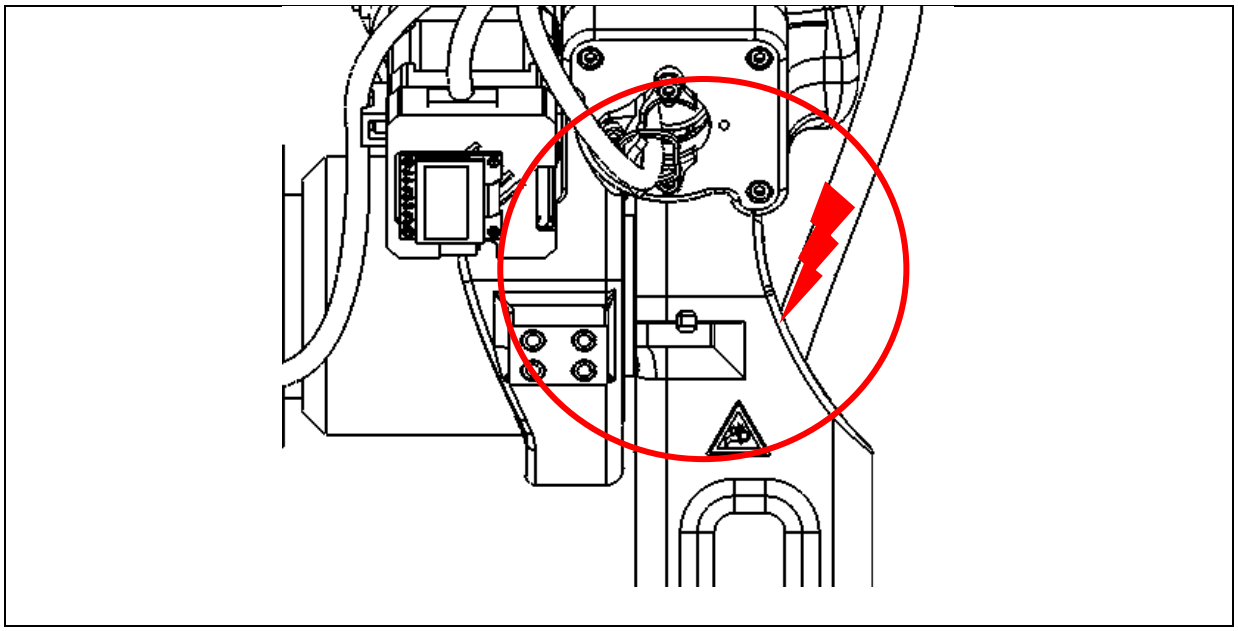


COMPRESSED AIR

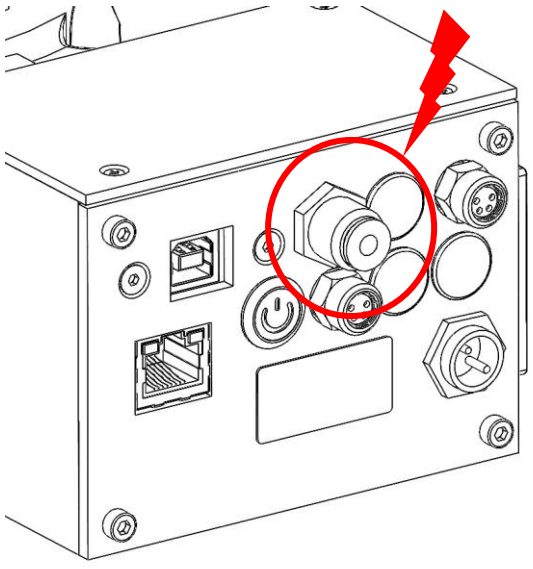


11.2.2 sssPinch or hand injury places

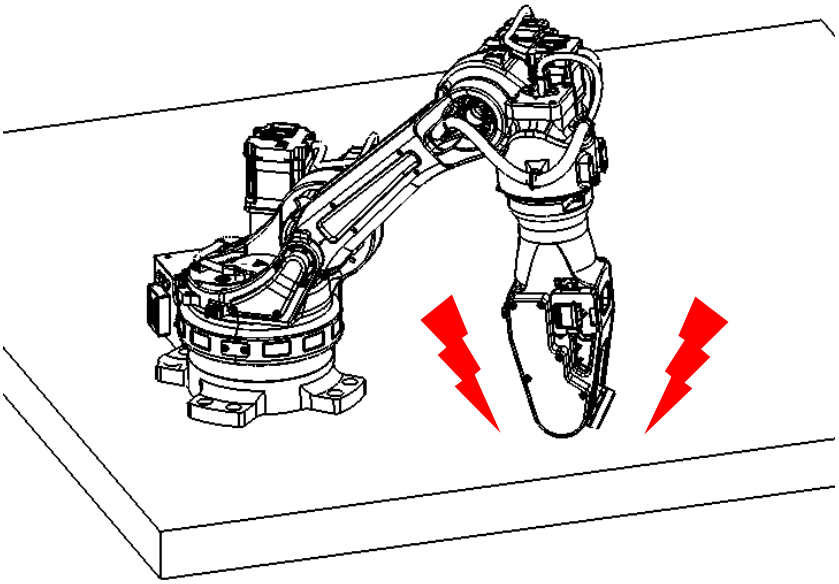
PINCH OR CRUSH INJURY – DO NOT PLACE ANY OBJECT ON THIS PLACE





11.2.3 Compressed air injury

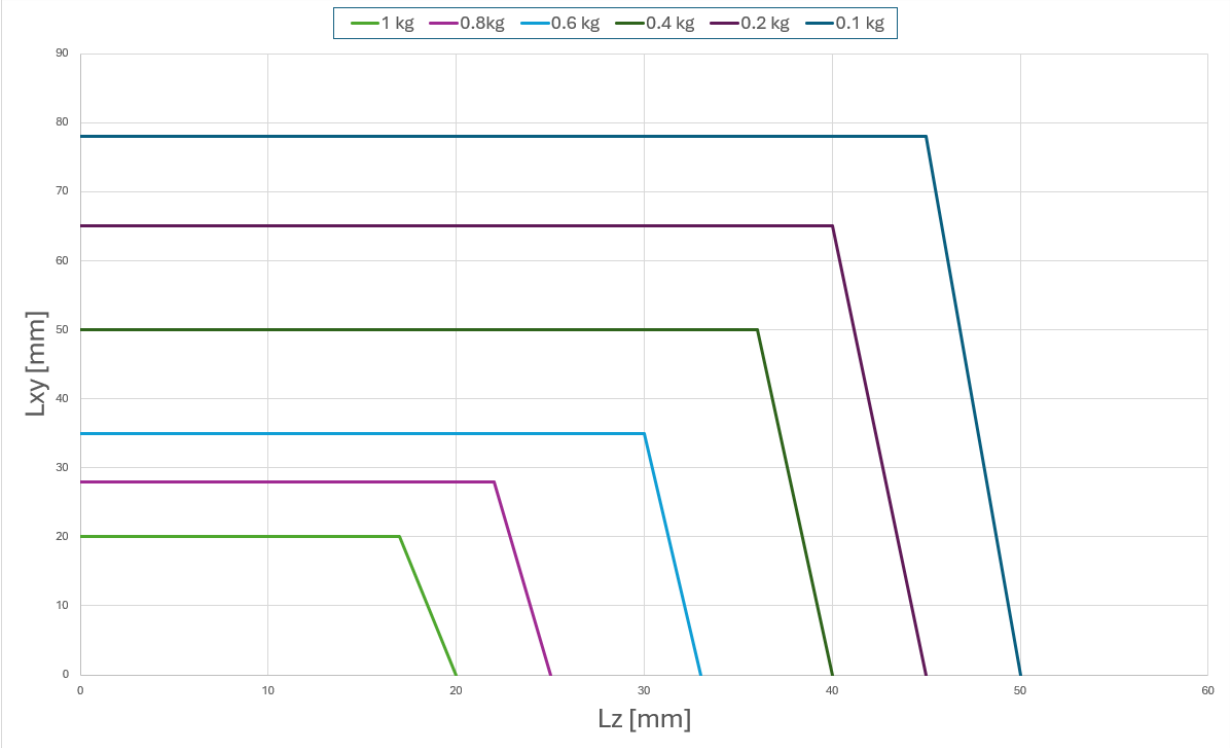
COMPRESSED AIR INJURY – IMPROPER RELEASE COULD RESULT IN INJURY


11.2.4 Residual risks in case of power loss



During power loss when there is heavy gripper installed JT5 might make a sudden movement!

Please note that when payload is restricted to this chart below none of the joints will be able to move by the force of gravity itself



11.3 Information on noise emissions

The level of emitted sound pressure at workstations, weighted according to the A characteristic, does not exceed 85 dB (A). The peak momentary value of sound pressure at workstations, weighted according to the C characteristic, does not exceed 63 Pa (130 dB in relation to 20 µPa).

12 Maintenance, support

12.1 Updating

The software version of the robot and the Firmware versions of the CPU can be updated in just a few steps using astorino application. For more information, follow the Operation Manual.

12.2 Maintenance and support

Kawasaki Robotics and Astor provides a support team dedicated to maintaining your robot and resolving technical problems. It will respond within 48 hours of your request.

Maintenance and repair procedures must be carried out in accordance with the general safety instructions and regulations and the rules set out by our support team.

It can also provide answers to your questions on how to operate the robot.

12.3 Warranty condition

All products manufactured by Astor that account as astorino ecosystem are guaranteed for one year from the date the invoice was issued. In the event of a warranty claim, provide the invoice, serial number, and photos and videos to explain the problem. We can then perform a remote diagnosis and help you resolve the problem.

12.4 Disposal

This robot complies with European Directive 2012/19/CE on used electrical and electronic appliances (waste electrical and electronic equipment – WEEE).

Disposal must be done in accordance with the laws in force in each country.

Do not dispose of your robot with the residual waste. Find out about the collection points for electronic and electrical devices near you.

13 Manufacturer information

For further questions, contact Kawasaki Robotics support.

Contact:

Kawasaki Robotics GmbH

tech-support@kawasakirobot.de

+49 (0) 2131 – 3426 – 1310

Kawasaki Robot
Safety Manual

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Appendix I

Safety Questionnaire for Working with the Astorino Educational Robot

Preliminary Legal Information

In accordance with the Machinery Directive 2006/42/EC, machines used in commercial environments must meet specific safety requirements. However, this directive provides an exception for machines intended for research and education, provided their purpose is clearly defined, and users are aware of the associated risks.

The Astorino robot, as an educational tool, is not equipped with a protective cage, which is justified by the need to ensure access and learning in a controlled environment. This questionnaire helps assess whether safety measures are sufficient and aligned with best practices and regulations.

Purpose of the Questionnaire:
To identify potential risks and ensure that safety measures comply with standards and best practices for working with educational robots.

Preliminary Information:

The Astorino robot is not enclosed in a protective cage, requiring special attention to safety. Completing this questionnaire will help identify areas for improvement and ensure a safe working environment in line with ISO 10218-1:2011 ("Industrial Robots - Safety Requirements").

Section 1: General Information

1.1. Teacher’s name:
1.2. Date of completion:
1.3. Robot's location of use:
1.4. Number of students present during the session:

Section 2: Training and Safety Procedures

2.1. Has the teacher undergone training on robot operation and safety? (YES/NO)
2.2. Is the teacher familiar with ISO 10218-1 safety standards for robots? (YES/NO)
2.3. Have students been trained in basic safety principles? (YES/NO)
2.4. Is a technical inspection of the robot performed before working with students? (YES/NO)

Section 3: Awareness of the Machinery Directive and Exceptions

3.1. Is the teacher aware that the Astorino robot is exempt from the full requirements of the Machinery Directive due to its educational purpose? (YES/NO)
3.2. Does the teacher understand that, under this exemption, some safety measures, such as a protective cage, may be omitted? (YES/NO)
3.3. Have risk-minimizing measures (e.g., collision detection, speed limitation) been implemented under this exemption? (YES/NO)

Section 4: Work Environment Assessment

4.1. Is the robot workstation adequately lit? (YES/NO)
4.2. Are there no obstacles or objects near the robot that could interfere with operation? (YES/NO)
4.3. Do students have sufficient space around the robot? (YES/NO)
4.4. Is the robot placed on a stable and secure surface? (YES/NO)

Section 5: Robot Operation Safety

5.1. Have students been informed about the robot's specific nature as an educational machine? (YES/NO)
5.2. Is the robot operating at a limited speed (max. 250 mm/s) according to educational safety principles? (YES/NO)
5.3. Is the collision detection function active and working properly? (YES/NO)
5.4. Is the robot used in accordance with the manufacturer’s recommendations and in a controlled educational environment? (YES/NO)
5.5. Is an emergency stop button available? (YES/NO)
5.6. Do students know how to react in an emergency? (YES/NO)
5.7. Are potential risks from working with the robot (e.g., collisions, pinching) known? (YES/NO)
5.8. Have students been informed that the robot is not enclosed in a protective cage? (YES/NO)
5.9. Does the teacher monitor the robot’s operation during the session? (YES/NO)

Section 6: Procedures in Case of a Hazard

6.1. Does the teacher know how to stop the robot in case of a malfunction or collision? (YES/NO)
6.2. Have students been instructed to report any unusual behaviour of the robot? (YES/NO)
6.3. Is an emergency stop button for the robot accessible? (YES/NO)

Section 7: Compliance Assessment

7.1. Have appropriate safety measures been implemented in the work environment despite exemptions from the full requirements of the Machinery Directive? (YES/NO)
7.2. Is the teacher aware of the potential risks associated with working with the educational robot (e.g., lack of a protective cage, risk of collision)? (YES/NO)
7.3. Are there procedures in place to enable quick stopping of the robot in the event of an incident? (YES/NO)

Section 8: Education and Training

8.1. Has the teacher undergone training on safety principles for working with educational machines? (YES/NO)
8.2. Are students informed about the specifics of the educational robot and associated risks? (YES/NO)
8.3. Does the teacher supervise the robot's operation during the session to minimize risks? (YES/NO)

Section 9: Opinions and Suggestions

9.1. Does the teacher consider the current safety measures sufficient for working with an educational machine? (YES/NO)
9.2. What additional safety measures could be implemented?
[Please provide detailed answers.]

Appendix: Information on the Machinery Directive

Machinery Directive 2006/42/EC:

- Applies to machines used in industrial environments.
- Exception: Machines intended for research and educational purposes can be used without full compliance with the directive, provided adequate protective measures are implemented.

Note: Users of educational robots should be aware of their limitations and specific usage characteristics to minimize risks. The robot manufacturer is obligated to provide full documentation and guidelines for safe operation.

Section 10: Signature and Acknowledgment

Signing this questionnaire confirms that the teacher is familiar with the safety principles, potential risks, and their responsibility to adhere to the rules for working with the robot.

Teacher's signature:

.....

Date:

.....

Appendix II

Risk Assessment for the Astorino Educational Robot and Additional Equipment

Astorino Robot

1. Workplace Characteristics

- Type of Robot: 6-axis educational robot.
- Application: Educational and laboratory use.
- Maximum Speed: 250 mm/s (software-limited).
- Safety Features:
  - Collision detection.
  - E-STOP buttons (emergency stop buttons).
  - Real-time algorithms monitoring and limiting the arm movement speed.
  - Stepper motors with inherently reduced torque at higher speeds.
  - Control system detecting abnormal movements.
- Work Environment:
  - Unfenced workstation with free access.
  - Operation takes place in the presence of students and an instructor/teacher.
  - Access to the workstation is controlled by the supervisor.

---

2. Detailed Hazard Identification

Robot Arm Movement

- Hazards:
  - Collisions with users, especially when the trajectory is not anticipated.
  - Crushing body parts in areas where the robot arm intersects with surroundings (crushing zones).
- Notes:

  - Lack of fencing increases the risk of accidental contact.
  - Crushing points occur at intersections of the robot arm with the ground, other objects, and on the robot arm itself—particularly near mechanical stops.
  - Speed limitation to 250 mm/s reduces impact force but does not eliminate injury risk.
- Protective Measures:
  - Speed limitation to 250 mm/s.
  - Collision detection.
  - Marking hazard zones on the robot and moving elements.
  - Supervisor awareness—monitoring students and enforcing safety procedures.

Control System Failure

- Hazard: Abnormal robot movements can cause sudden and uncontrolled arm motions.
- Risk Assessment: Low (due to real-time monitoring of abnormal movements).
- Protective Measures:
  - Control algorithms detecting anomalies.
  - Automatic robot stop in case of irregularities.

Electrical Failure of Motor Controllers

- Hazard: Potential failure causing damage to electronic systems (burnt-out controller), risk of short circuit.
- Risk Assessment: Very Low (controller failures are rare).
- Protective Measures:
  - Regular inspections of the electrical system.
  - Overload protection and fuses.
  - Proper cooling of controllers.

Singularities in 6-Axis Robots

- Hazard: At singularities (e.g., axis straightening), sudden and unpredictable arm movements may occur, leading to collisions.
- Risk Assessment: Medium.
- Protective Measures:
  - Speed limitation of axes in the control system.
  - Slowing down the overall arm motion to a safe level near singularities.
  - Real-time kinematics monitoring and motion path optimization.

Robot Arm Speed

- Hazard: Exceeding 250 mm/s increases the risk of severe collisions and injuries.
- Protective Measures:
  - Mechanical axis speed limitation (stepper motors reduce torque at high speeds).
  - Real-time algorithms monitoring arm speed:
    - Automatic speed limitation to ensure it does not exceed 250 mm/s.

Mechanical Failure

- Hazards:
  - Mechanical component damage leading to uncontrolled movements.
  - Oil or grease leaks that may cause slips or workstation contamination.

Pneumatic System

- Hazards:
  - Air leaks causing unexpected gripper movements.
  - Sudden pressure drops leading to uncontrolled gripper release.

Electrical System

- Hazards:
    - Electric shock risk due to damaged insulation.
    - Fire risk in case of electrical short circuit.

User Interaction

- Hazards:
    - Lack of user experience leading to incorrect commands issued to the robot.
    - Improper workspace preparation, e.g., leaving objects that may accidentally be displaced by the robot.

Lack of Fencing

- Hazards:
    - Accidental entry of unauthorized persons into the robot's working area.
    - Risk of collisions in case of user distraction.

---

3. Detailed Risk Analysis

Severity (S): How severe the consequences of the hazard could be (1: low, 4: very high).

Likelihood (L): How likely the hazard is to occur (1: unlikely, 4: very likely).

Risk Level (RL): S x L (1-3: acceptable, 4-8: requires action, 9-16: unacceptable).

Hazard	Severity (S)	Likelihood (L)	Risk Level (RL)	Remarks and Mitigations
Robot arm collisions	2	3	6	Speed limitation, marking work zones, virtual motion limits.
Finger entrapment in gripper	2	2	4	Limiting gripper force, pre-operation tests, emergency stop system.

Hazard	Severity (S)	Likelihood (L)	Risk Level (RL)	Remarks and Mitigations
Air leaks (pneumatic gripper)	2	2	4	Regular maintenance, use of safety and check valves.
Electric shock	4	1	4	Inspection of electrical wiring, use of certified equipment.
Mechanical failure	3	1	3	Regular inspection of 3D printed components, replacing worn mechanical parts.
Lack of procedural knowledge	3	4	12	User training, instructor supervision, restricted access to control panels.
Finger crushing	3	2	6	Hazard zone marking, supervisor monitoring, collision detection.
Control system failure	2	2	4	Detecting abnormal movements, automatic robot stop.
Electrical failure of motor controllers	3	1	3	Overload protections, regular inspections,
Singularities—sudden arm movement	3	1	3	Speed reduction near singularities, kinematics monitoring.
Robot arm speed	3	1	3	Mechanical and software-based speed limits, real-time speed monitoring.

4. Control Measures and Safety Procedures

Technical Measures

1. Work Zone Limitations:
    - Use of virtual motion limits in robot control.
    - Clear marking of work zones (e.g., yellow lines around the robot).
2. Grippers:
    - Configure gripper force appropriate for educational use (minimum required force).
    - Pre-operation gripper testing.
3. E-STOP Buttons:
    - Verify button placement for accessibility from any workstation location.
4. Electrical System:
    - Inspect wiring insulation.
    - Overload protections for all electrical subsystems.

Organizational Measures

1. User Training:
    - Mandatory training on robot and gripper operation.
    - Emergency system usage exercises (e.g., E-STOP).
    - Procedures for pneumatic, electrical, and vacuum system failures.
2. Access Control:
    - Restricted access to the workstation for trained users under instructor supervision.

Procedural Measures

1. Maintenance:
    - Regular technical inspections of all robot subsystems.
    - Inspection of grippers, pneumatic systems, and electrical wiring.
2. System Testing:

- Simulating motions before real-time execution.
- Verifying speed and force limitations adherence.

5. Conclusions

The educational robot workstation can be safe provided that detailed technical, organizational, and procedural measures are implemented. Due to the absence of collaborative robot features, key factors include user training and instructor supervision. Additional safety measures, such as virtual motion limits and work area markings, should be considered.

In reference to ISO/TS 15066, the maximum force that can act on the human body must not exceed **140 N**; the Astorino robot is capable of generating a maximum contact force of **102 N**.

Key Risks:
Finger crushing, singularities, and sudden movements of pneumatic equipment.

Additional Equipment

1. Workplace Characteristics (Expanded)

Grippers:

1. **Electric:**
   - Power Supply: **24V**.
   - Maximum gripping force: **8N**.
   - Ability to limit maximum force.
2. **Magnetic:**
   - Uses an electromagnet with a force of **20N**.
   - **Potential risk of overheating** the electromagnet during prolonged operation.
   - Attraction of metallic objects outside the working area.
   - Risk of dropping the object in case of power failure.
3. **Vacuum Gripper:**
   - Uses vacuum to hold objects.
   - Maximum holding force: **5N** (4 Bar).
   - Requires tight connections and a functioning vacuum generation system.
   - Risks associated with dropping objects in case of vacuum loss.
   - Risks related to noise from the vacuum generator.
4. **Pneumatic Gripper:**
   - Uses compressed air pressure to hold objects.
   - Requires tight connections and a functioning pneumatic system.
   - Risks associated with dropping objects in case of pressure loss.
   - Maximum gripping force: **15.2N** (4 Bar).
5. **Additional Equipment – Cube Feeder:**
   - Equipped with a pneumatic actuator for moving or feeding cubes.

- Automates the feeding process but introduces additional risks from the pneumatic actuator (e.g., uncontrolled movements, air leaks).
- Maximum actuator force: **31N** (4 Bar).

---

2. Detailed Hazard Identification

Robot Arm Movement

Hazards common to all types of grippers and equipment:

- Collisions between the robot arm and users during movement.
- Crushing body parts in points where the robot intersects with the equipment.

Electric Grippers

- **Hazards:**
  - Finger entrapment at a maximum force of **8N**.
  - Electrical failure (short circuits, overheating of power cables).
  - Software errors leading to uncontrolled gripper closure.

Magnetic Grippers

- **Hazards:**
  - Overheating of the electromagnet during prolonged operation, leading to burns upon contact or equipment damage.
  - Unforeseen attraction of metallic objects from outside the working area.
  - Risk of sudden object release in case of power failure.

Vacuum Grippers

- **Hazards:**
  - Vacuum loss caused by system leaks or pump failure.
  - Dropping objects on users or workstation components.
  - Noise generated by the vacuum pump (may exceed workplace noise standards).

Pneumatic Grippers

- **Hazards:**
  - Pressure loss due to system leaks or compressor failure.
  - Dropping objects on users or workstation components.
  - Finger entrapment at a maximum force of **15.2N**.

Cube Feeder with Pneumatic Actuator

- **Hazards:**
  - Sudden, uncontrolled actuator movements in case of failure.
  - Entrapment of hands or body parts by the actuator or moving cubes, with a maximum force of **31N**.
  - Air leaks reducing system effectiveness and causing unexpected behaviour.
  - Possibility of cubes being ejected at high speeds, posing a danger to users.

---

3. Detailed Risk Analysis

Risk Matrix (Severity x Likelihood):

- **Severity (S):** How severe the hazard consequences are (1: Low, 4: Very High).
- **Likelihood (L):** Probability of the hazard occurring (1: Unlikely, 4: Very Likely).
- **Risk Level (RL):** S x L (1-3: Acceptable, 4-8: Requires Action, 9-16: Unacceptable).

Hazard	Severity (S)	Likelihood (L)	Risk Level (RL)	Remarks and Mitigations
Finger entrapment by electric gripper	2	2	4	Limit gripping force to the minimum required for manipulation.

Hazard	Severity (S)	Likelihood (L)	Risk Level (RL)	Remarks and Mitigations
Finger entrapment by pneumatic gripper	2	2	4	Limit gripping force, mark hazard zones, and train users.
Unexpected closure of pneumatic gripper	2	2	4	Regular maintenance of pneumatic valves, verify valve operation.
Electrical failure of gripper	3	1	3	Regular inspection of cables and connectors, introduce safety procedures for power failure.
Electromagnet overheating in magnetic gripper	3	2	6	Limit continuous electromagnet operation time, train users.
Attraction of metallic objects by magnetic gripper	3	1	3	Mark working zones to keep loose metallic objects away. Limited magnetic force
Object release by vacuum gripper	3	2	6	Regular vacuum system leak checks; double safety measures for heavy objects.
Object release by magnetic gripper	3	1	3	Match objects to the gripper’s holding force.
Noise generated by vacuum pump	2	2	4	Use noise dampers on the vacuum pump outlet.
Uncontrolled actuator movements in cube feeder	3	2	6	Use dampening-return valves; conduct regular maintenance of the pneumatic system.

Hazard	Se-verity (S)	Likeli-hood (L)	Risk Level (RL)	Remarks and Mitigations
Finger entrap-ment by cube feeder actuator	3	2	6	Limit actuator force and clearly mark the cube feeder's working zone, train users.
Cube ejection at high speed	2	3	6	Introduce dampening-return valves to limit actuator speed and prevent cubes from leaving the work area.
Air leaks in the pneumatic sys-tem	2	2	4	Check pneumatic system seals regularly and use high-quality connectors.
Overpressure in pneumatic sys-tems (>4 Bar)	4	3	12	Train users, use appropriate compressed air equipment (<4 Bar).

4. Control Measures and Safety Procedures

Technical Measures:

1. **Electric Grippers:**
   - Configure gripper to limit gripping force.
   - Use collision detection to monitor excessive gripping force.
2. **Magnetic Grippers:**
   - Train users on safe operation.
   - Limit continuous operation time of the electromagnet.
3. **Vacuum Grippers:**
   - Regularly check for leaks in the vacuum system.
   - Uses noise dampers and limits the noise to maximum level of 56 dB (8 Bar)
4. **Pneumatic Gripper:**
   - Monitor and maintain tightness of the pneumatic system.
5. **Cube Feeder with Pneumatic Actuator:**

- Use dampening-return valves to prevent sudden and uncontrolled movements.
- Add noise dampers for pneumatic system operation.

Organizational Measures:

1. **User Training:**
   - Mandatory training on the operation of the robot and equipment (grippers and cube feeder).
   - Procedures for handling pneumatic, electrical, and vacuum system failures.
2. **Access Control:**
   - Access restricted to trained users under instructor supervision.

Procedural Measures:

1. **Maintenance:**
   - Regular inspections of mechanical, electrical, and pneumatic systems.
   - Verify proper operation of all grippers.
2. **Emergency Procedures:**
   - Implement quick gripper shutdown procedures (e.g., nearby E-STOP button).

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5. Conclusions

The use of additional grippers (electric, magnetic, vacuum, and pneumatic) and the cube feeder increases workstation complexity and introduces new hazards. The key factors are:

- **Regular maintenance** of gripper and feeder systems.
- **Risk reduction through technical measures** (e.g., force limitation, safety valves).
- **User training** on equipment operation and safety procedures.
- **Using equipment within specified operating parameters.**

- **In reference to ISO/TS 15066**, the maximum force that can act on the human body must not exceed **140 N**; no additional equipment is capable of generating such force.

Appendix III

Guidelines for Teachers on Working with the Astorino Educational Robot

1. Introduction

The Astorino educational robot is not equipped with a protective cage, requiring special attention when used in an educational environment. The teacher is responsible for ensuring safe working conditions and adhering to the appropriate procedures.

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2. Training and Safety Procedures

- Teachers should undergo training on robot operation and safety principles.
- Familiarity with ISO 10218-1:2011 safety standards for industrial robots is recommended.
- A technical inspection of the robot should be performed before working with students.
- Students must be trained in basic safety principles.

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3. Awareness of the Machinery Directive

- The lack of a protective cage is due to the need to ensure accessibility in a controlled learning environment.
- Risk-minimizing measures, such as collision detection and speed limitation, must be active and functional.
- The Astorino robot is an educational device and must not be used for industrial purposes.
- The minimum recommended age for users is 16 years old. Younger students may have difficulty using and programming the robot safely.

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4. Work Environment Assessment

- The robot workstation should be well-lit.
- No obstacles or objects should be near the robot that could interfere with its operation.

- Students must have adequate space around the robot.
- The robot should be placed on a stable and secure surface.
- The robot should not be used outdoors or in environments with dust, moisture, or strong electromagnetic fields.

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5. Safe Operation of the Robot

- Students must be informed about the specific nature of the robot as an educational machine.
- The robot's speed is limited to a maximum of 250 mm/s in accordance with educational safety principles.
- The collision detection function must be active.
- The robot must be used according to the manufacturer’s recommendations in a controlled educational environment.
- An emergency stop button must be available and functional.
- Students must know how to react in an emergency.
- Potential hazards (e.g., collisions, pinching, entanglement of loose clothing or hair) must be known to all participants.
- The teacher must constantly monitor the robot’s operation during sessions.
- In the event of a power failure, certain axes may unexpectedly lower, particularly if heavy grippers are mounted.

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6. Procedures in Case of a Hazard

- Teachers should know how to stop the robot in case of a malfunction or collision.
- Students must be informed about the necessity of reporting any unusual robot behaviour.
- The emergency stop button must be easily accessible.
- In case of power loss or control system failure, the robot may make unexpected movements—users should exercise caution.

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7. Compliance with Safety Standards

- Teachers should be aware of potential risks associated with working with the educational robot.
- There must be procedures in place for the quick stopping of the robot in emergency situations.

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8. Education and Supervision

- Teachers should undergo training on safety principles for educational machines.
- Students must be aware of the robot's specific features and associated risks.
- Teachers must supervise the robot's operation to minimize risks.

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9. Additional Safety Measures

- Teachers should regularly evaluate the effectiveness of current safety procedures.
- Any additional safety measures should be implemented as needed.
- The robot should only be used within its specified parameters, and any attempts to modify control settings are prohibited.

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10. Conclusion

Working with the Astorino educational robot requires special attention to safety. Awareness of potential hazards, implementation of appropriate procedures, and supervision of students are key to ensuring a safe and effective educational environment.