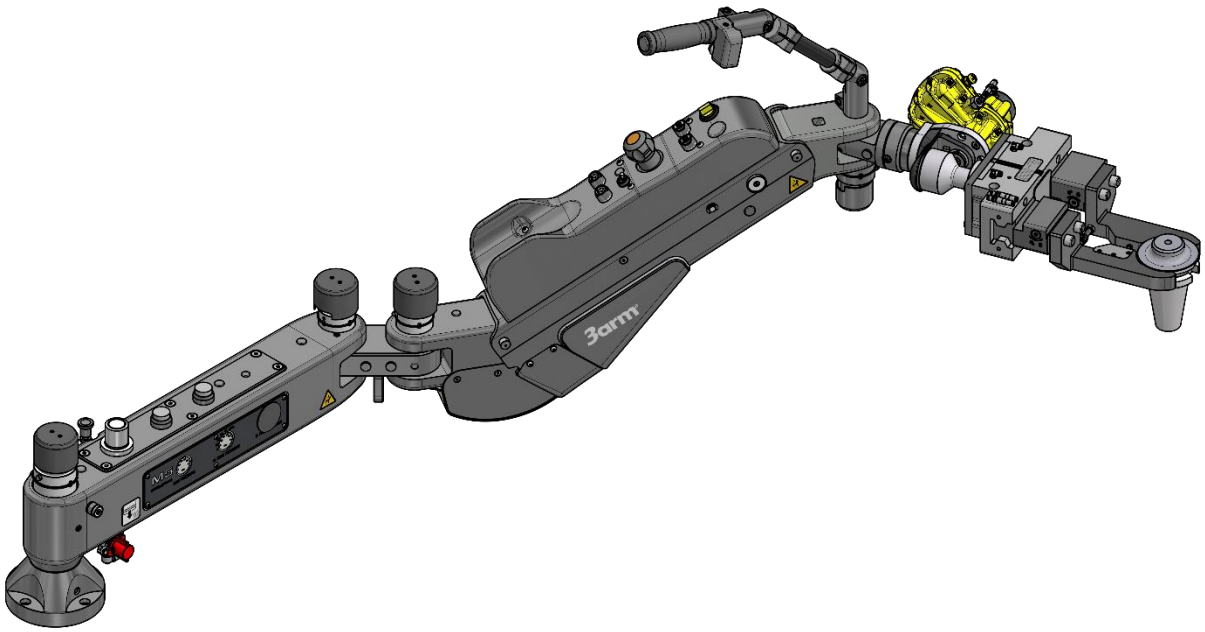
INSTRUCTION MANUAL

MANIPULATOR M5

3arm®



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DESIGN & QUALITY
3arm
Made in Barcelona

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1 INTRODUCTION

Dear Customer,

Congratulations to you on your choice and congratulations to the dedicated people at Tecnospiro Machine Tool for their continuous efforts on improving ergonomics at work.

We hope these simple instructions will be helpful for you for starting and operating the manipulator. We suggest you pay special attention to the pages on the concepts of installation, safety and maintenance.

We hope your manipulator will have a long life and that you can reaffirm the very good investment you have made in acquiring this product.

2 ABOUT THIS MANUAL

This document corresponds to the M5 Manipulator instruction manual.

- ORIGINAL MANUAL –

Intellectual/Industrial Property Information:

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2.1 CONSIDERATIONS

- ✓ Before using the equipment, be sure to read this instruction manual and follow the instructions for use and safety correctly.
- ✓ All the instructions listed in this manual refer to the individual unit. It is the end user's responsibility to analyse and apply all the necessary safety measures required for the end use.
- ✓ This manual must be kept for the entire life of the equipment, in a place close to it for future consultations.
- ✓ If any part of this manual is unclear, confusing or inaccurate, please do not hesitate to contact us.
- ✓ The content of this manual may be subject to change without prior notice.
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- ✓ The illustrations shown in this manual may differ in some details from its specific configuration and should be understood as a standard representation.

Paragraphs indicating assembly, adjustment, installation or maintenance steps are framed with a brown background.

Paragraphs with highlighted information are framed with a grey background.

2.2 DOCUMENT VERSION

Document	Date - version
Instruction manual M5 Manipulator	27/05/2024

3 SAFETY INFORMATION

3.1 SCOPE OF APPLICATION

This section contains very important information related to the safety of your manipulator, it is addressed to all personnel involved in any of the life phases of this equipment (transport, assembly and installation, commissioning, adjustment, learning, operation, cleaning, maintenance, fault finding/detection, dismantling/de-commissioning).

3.2 ALERTS AND GENERAL CONSIDERATIONS

- ✓ The equipment described in this document has been built in accordance with the current technological level and in accordance with the applicable technical standards in terms of safety. However, improper use, or incorrect integration by the end user can generate risk of injury.

- ✓ The equipment must only be used in perfect technical condition, respecting the safety regulations and the instructions provided in this document.

- ✓ Any breakdown that may affect safety must be corrected immediately.

- ✓ Without the proper authorisation of TECNOSPIRO MACHINE TOOL, S.L.U. No modification of equipment should be made.

- ✓ The equipment must only be operated for its intended use. Any other use is strictly prohibited. Any use other than that indicated is considered misuse and is prohibited. The manufacturer assumes no responsibility for any damage that may arise from this. This is solely at the user's own risk.

- ✓ Do not use the equipment in any way that is not considered in this manual and pay special attention to the uses mentioned in section 3.3 EXCLUSIONS, which must not be carried out.

- ✓ The operator must only use the equipment after having received the instructions for its use.

- ✓ The integrator/end user must ensure that the load-mounting device is suitable for the end application.

- ✓ Do not exceed the maximum working load limits (WLL) indicated in this manual and on the manipulator's identification plate.

- ✓ It is recommended that only one operator use the manipulator at a time, any other use must be evaluated by the integrator/end user.

- ✓ When it is not in use, it must be left in the retracted or parking position. Ensure the air supply to the

equipment has been cut off at the end of the working day.

- ✓ The operator may only use the manipulator for safe movements, accompanying the movement of the equipment at all times, and thus reducing the risk of uncontrolled or involuntary movements of the manipulator and/or the load.

- ✓ Although the parts with a higher risk of possible shearing or mechanical gripping are protected and have guards, it is forbidden to manipulate the moving components and joints when it is in use.

- ✓ The operator must remain outside of the vertical path of the swivel arm.

- ✓ The work area of the manipulator and its surrounding area must respect safety, health and hygiene at work conditions. It is the integrator/end user's responsibility to conduct a study to guarantee safety.

- ✓ The presence of third parties in the manipulator's work area must be restricted as much as possible, thus avoiding any impact on safety. For any other use, an additional study of the hazards derived from this way of working must be carried out.
- ✓ Only authorised personnel may be present in this area while the manipulator is in use.

- ✓ It is important that the users who operate this manipulator are familiar with and sufficiently trained to use this product or similar products.

- ✓ It is recommended that the operator have basic knowledge of: Safety procedures, precautions, safe work habits and cargo handling.

- ✓ In any case, the operator must read and understand this manual before use regardless of their knowledge, training or experience with similar equipment, especially the sections dedicated to installation, operation and safety.

- ✓ It is the responsibility of the integrator, owner and/or end user to determine the suitability of the product for each use, as well as its place of installation and the specific definition of the task to be carried out with this product within the limits stated in this manual.

- ✓ The devices for manipulation and loading may be subject to different regulations in every country. These regulations may not be specified in this manual.

- ✓ The appropriate distances that allow people to circulate safely must be added around the perimeter of the equipment. The work areas must be kept clear of obstacles, columns, etc. that could hinder the work of the operators.

- ✓ For tasks of maintenance, adjustment, cleaning, etc. there must be the spaces necessary for these tasks.

- ✓ If you have questions about handling or maintenance procedures, please

contact the authorised technical service.

3.3 EXCLUSIONS

The following is beyond the scope of use of this manipulator:

- ✓ Handling loads whose nature could lead to hazardous situations (molten metal, acids/alkalines, radioactive material, especially fragile loads).
- ✓ Operation subject to special rules described in chapter 1 of the standard UNE-EN 14238:2005+A1, related to "Cranes. Manually controlled load manipulating devices".
- ✓ Operation in severe conditions (e.g. extreme environmental conditions such as freezing, high temperatures, corrosive environment, strong magnetic fields).
- ✓ Loads greater than the maximum working load limits (WLL).
- ✓ Lifting and/or handling of people or animals.
- ✓ Use in areas with risk of explosion.
- ✓ Installation in outdoor areas.
- ✓ Handling of any component or functions of the equipment outside of those specified in this manual.
- ✓ Use by people with some type of disability or by animals.

3.4 SYSTEM INTEGRATOR

The system's integrator or end user is responsible for integrating the machine in the installation, respecting all the relevant safety measures.

The integrator/end user is responsible for the following tasks:

- ✓ Siting of the manipulator.
- ✓ Connections of the manipulator.
- ✓ Risk assessment.
- ✓ Facilities with the necessary safety and protection functions.
- ✓ Issue of the EC statement of compliance.
- ✓ Placement of the CE marking.
- ✓ Preparing the machine's service instructions.

3.5 SYMBOLOGY AND ICONS

Throughout this manual and in the structure of the machine, different symbols and pictograms can be observed, the meaning of which is summarised below.

	General danger symbol. This symbol is usually accompanied by another symbol, or a more detailed description of the danger.
	Trapping hazard

3.6 PERSONAL PROTECTION EQUIPMENT (PPE)

The personal protection equipment for the manipulator is merely safety footwear for all stages of the life of the equipment.

It is the integrator/end user's responsibility to define the personal protection equipment derived from the final

application of the equipment, in order to comply with the essential health, safety and hygiene requirements.

Operators should not wear loose clothing, rings or bracelets that may fall within the mechanism of the equipment.

It is also mandatory to wear the hair collected to avoid snags with the moving parts of the equipment.

3.7 TRAINING LEVEL OF THE STAFF INVOLVED

All people working with the equipment must have read and understood the safety chapter of the documentation.

The minimum level of training to use the manipulator shall be:

- Production workers: occupational risk prevention course, full training on work stations and residual risks of the equipment. Minimum of one year's experience in similar facilities.

- Maintenance workers: Occupational risk prevention course, complete training in handling, operation, maintenance and conservation of equipment and residual risks. Minimum of two years' experience in similar facilities and with the technical level necessary to perform tasks without problems.

- Cleaning operators: Occupational risk prevention course, training on products and procedures for carrying out cleaning tasks.

- Apprentices/students: They may only work on the equipment if supervised at all times by one of the facility's suitably qualified employees.

- Public (non-operators): Visitors or passers-by must maintain a minimum safety distance of two metres from the edges of the perimeter of the equipment.

3.8 RESIDUAL RISKS

The residual risks of the equipment would be:

- ✓ Trapping, hitting or crushing a hand due to accessing the moving tooling assembly, either during the opening/closing operation or in the rotation/turning operation.

- ✓ Hitting or crushing a hand or foot due to the part released from the tooling assembly falling.

- ✓ Hitting or crushing during the displacement of the manipulator's own arm.

- ✓ Hitting or cutting by the structure of the manipulator arm itself.

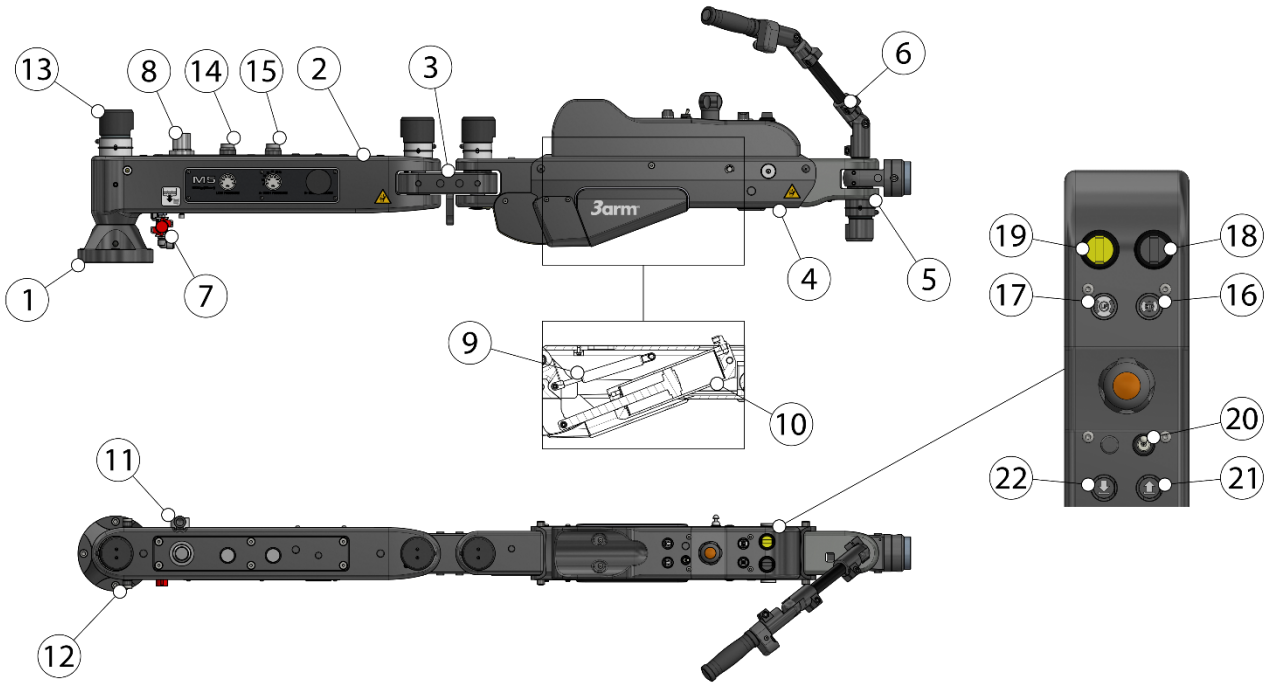
- ✓ Entrapment, impact and/or crushing due to the manipulator falling or overturning.

- ✓ Ergonomic hazards.

4 GENERAL DESCRIPTION AND TECHNICAL INFORMATION

The manual control load handling device consists of a pendular parallelogram. Balanced with a gas spring and a pneumatic cylinder, plus a radial arm. The assembly of both secures the clamping head and keeps it in a perpendicular position to the work area. It equips different systems such as a knob and a safety grip, which also help to govern the manipulator. To make it functional, different load securing devices must be added with which a final product that can be adapted to different working conditions can be obtained.

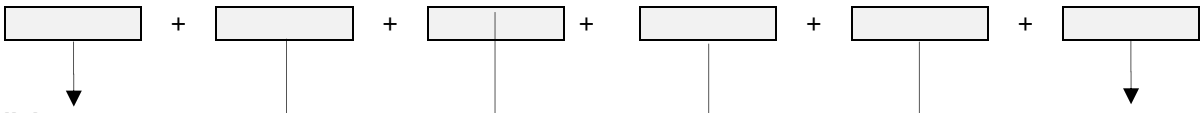
4.1 MAIN PARTS



1.- Base
2.- Radial arm
3.- Tilting arm
4 - Joint
5.- Head
6.- Handle - Handlebars
7.- Safety valve
8.-Power supply regulator (R1)
9.-Gas spring
10.- Pneumatic cylinder
11.- Lock
12.- Magnet (Folded position)
13.- Pneumatic locks
14.- Regulator without load (R2)
15 - Load regulator (R3)
16.- Activate actuator and high pressure
17.- Deactivate actuator and low pressure
18.- Rotating
19. - Revolving
20.- Lock
21.- Raise lifter
22.- Lower lifter

4.2 CONFIGURATIONS

4.2.1 CONFIGURATION TABLE



Radial arm + Arm

PB5	Tabletop
PT5	Ceiling-mounted
PX5	Customised

Lift

-	Without lift
E	With lift

Head

CA5	Horizontal Head
CC5	Revolving head 90º
CC5X	Revolving head custom Xº
CD5	Vertical head
CE5	Manual Rotating Head with lock
CF5	90º Revolving Head + M. Rotating
CF5X	Revolving Xº Head + M. Rotating
CG511	Revolving Head 90º + Rotating 90º
CG512	Revolving Head 90º + Rotating 180º
CG513	Revolving Head 90º + Rotating 270º
CG5X1	Revolving Head Xº + Rotating 90º
CG5X2	Revolving Head Xº + Rotating 180º
CG5X3	Revolving Head Xº + Rotating 270º
CH51	Short Rotating Head 90º
CH52	Short Rotating Head 180º
CH53	Short Rotating Head 270º
CI5	Manual Rotating Head
CX5	Customised Head

Arm lock

L0	No lock
L2	Pneumatic lock
LX	Customised lock

Handlebar

MA5	Single handlebar
MB5	Double handlebar
MC5	No handlebar
MD5	Automatic double handlebar
ME5	Vertical handlebar (only with CD5)
MX5	Custom handlebar

Pneumatic system

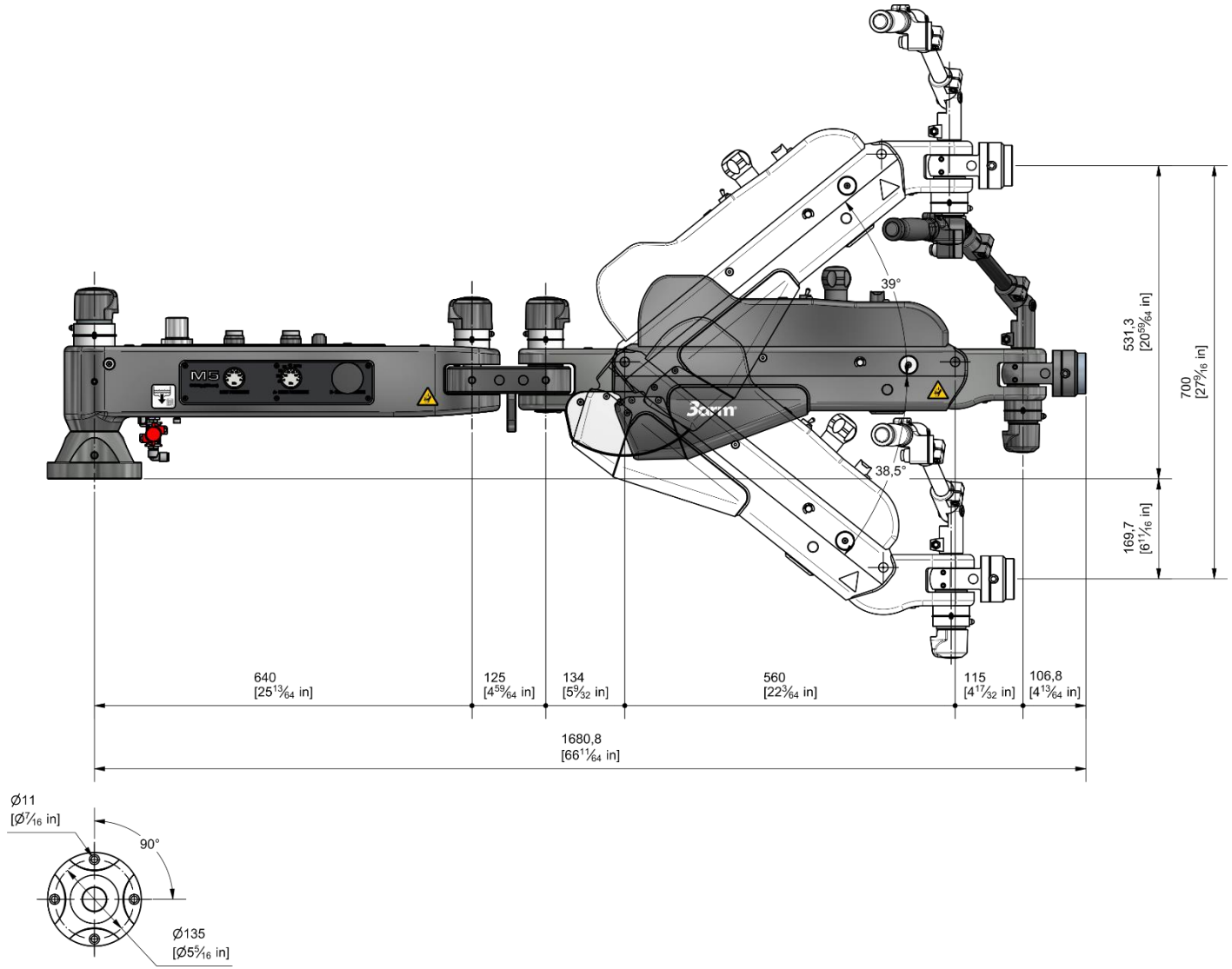
Code	Effect	Rotation	No. high pressures
NA5	Basic	0	1
NB5	Actuator	0	1
NC5	Actuator	1	1
ND5	Actuator	2	1
NE5	Suction cup	0	1
NF5	Suction cup	1	1
NG5	Suction cup	2	1
NH5	Basic	1	1
NI5	Basic	2	1
NJ5	Basic	0	2
NK5	Basic	1	2
NL5	Basic	2	2
NM5	Actuator	0	2
NN5	Actuator	1	2
NO5	Actuator	2	2
NP5	Suction cup	0	2
NQ5	Suction cup	1	2
NR5	Suction cup	2	2
NX5	Customised		

4.2.2 ORDER EXAMPLE

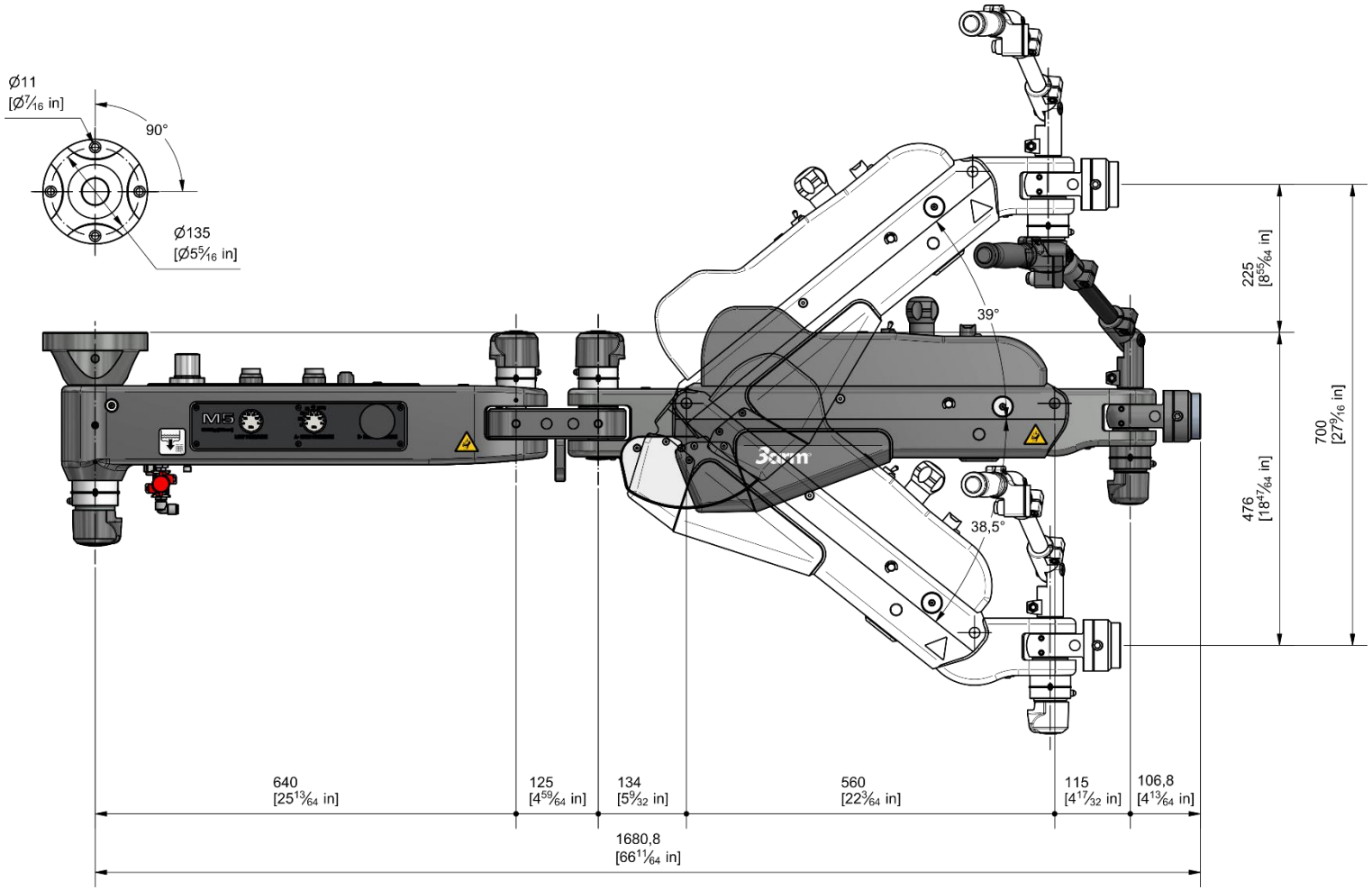
Order example: **MANIPULATOR M5- PB5+CE51+MA5+NC5+L0 + E (XX kg)**
XX= Weight of head and load-securing device.

4.3 GENERAL DIMENSIONS

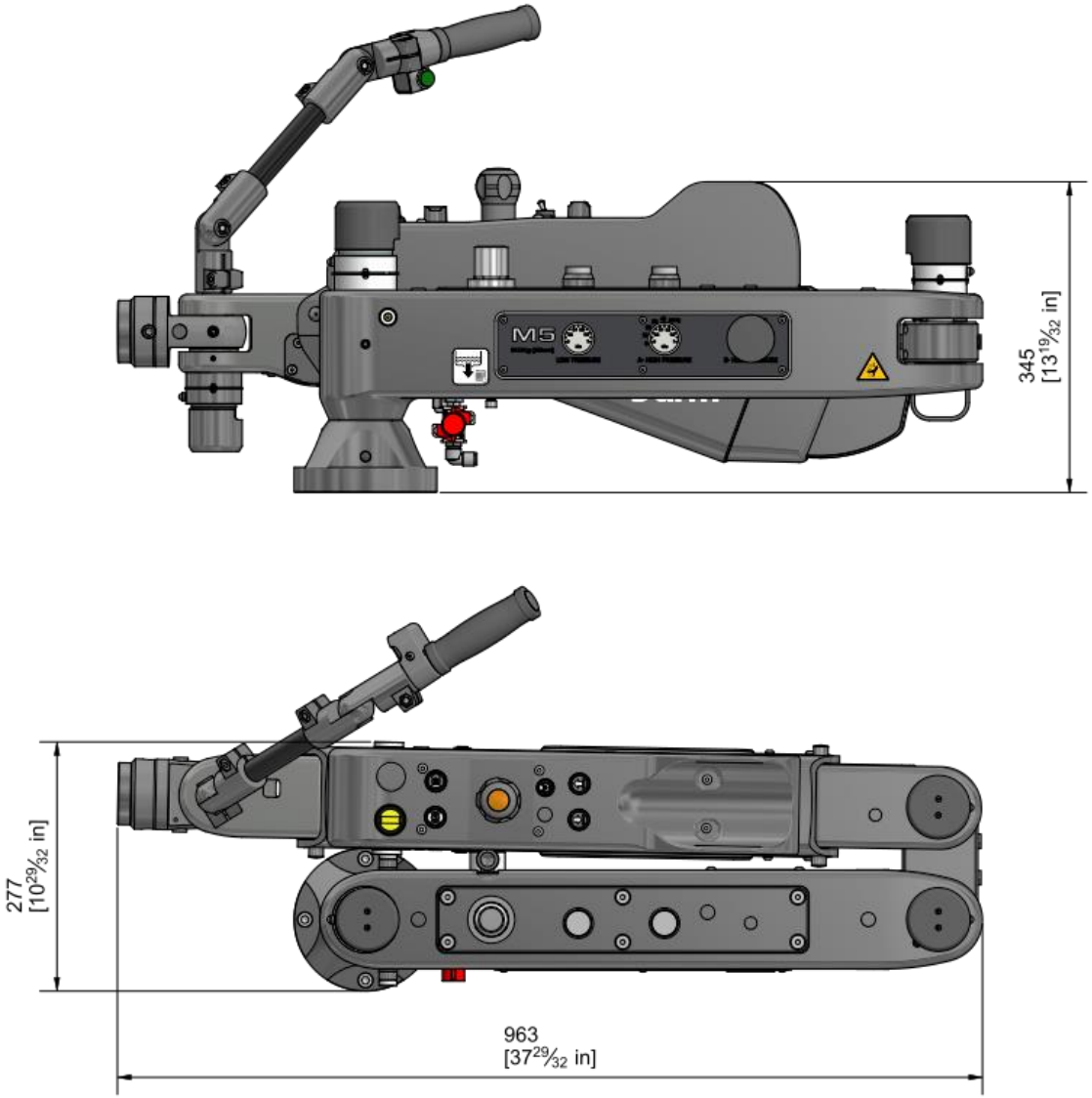
4.3.1 Extended position (Tabletop version)



4.3.2 Extended position (Ceiling-mounted version)

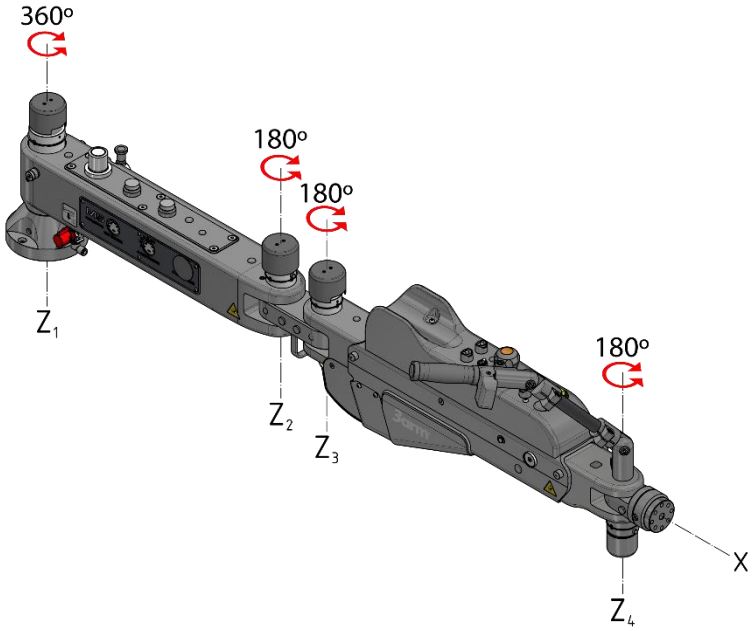


4.3.3 Retracted position – Parking



4.4 MOVEMENTS

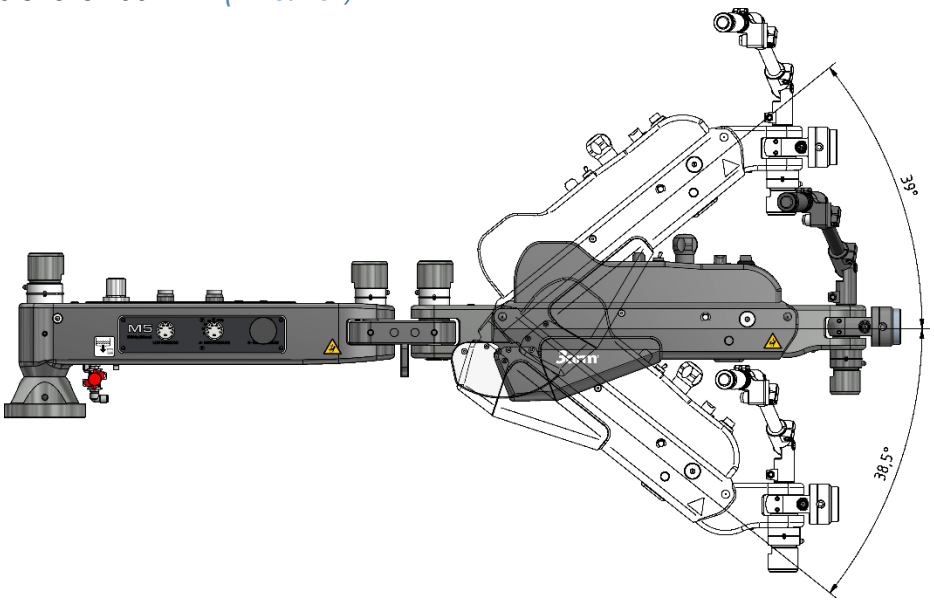
4.4.1 Arm and radial arm movements



Base rotation - radial arm: 360º (Z_1 axis)
Radial arm – joint rotation movement: 180º (Z_2 axis)
Joint – arm rotation movement: 180º (Z_3 axis)
Head rotation movement: 180º (Z_4 axis).
Head rotation movement[1]: 360º (4x90º) (X axis)

4.4.2 Ascending and descending arm movements

The arm can move from -38.5º to + 39º from the horizontal.
The vertical stroke is 700 mm. *(27 9/16")*



This movement is made by the operator, although the weightless system facilitates it.

[1] May vary depending on the head chosen.

4.5 CONSIDERATIONS OF USE

The equipment should only be operated for its intended use. Any other use is forbidden [See GENERAL WARNINGS AND CONSIDERATIONS page 6].

The manipulator must only be used with the type of loads that have been considered in its design, without exceeding the working load limit (WLL) indicated in the technical specifications and in the identification plate of the equipment.

Only one operator can work with this manipulator at a time and must use safe movements and transitions.

The manipulator is designed for fast, controlled and repetitive load handling.

4.6 DESIGN CONSIDERATIONS

The manipulator has been designed applying the mechanical resistance requirements corresponding to the standard UNE-EN 13001-1:2006+A1:2009/AC: 2010EN and UNE-EN 13001-2:2006+A1:2009/AC: 2010.

All parts and components accessible to the operator have been manufactured without sharp edges or angles that could cause injury.

All the indications of the UNE-EN 14238:2005+A1:2010EN standard, regarding ergonomics and noise emission, have been considered.

4.7 TECHNICAL SPECIFICATIONS

4.7.1 General technical specifications

GENERAL TECHNICAL SPECIFICATIONS		
Dimensions and mass		
	Height	345 mm *(13.6")*
	Length	963 mm *(37.9")*
	Width	283 mm *(11.2")*
	Mass	48 kg *(106 lb)*
Movements		
	ZX Plan	+39º / -38.5º
	XY working radius	1680 mm *(66.1")*
	$Z_{1\ axis}$	360º
	$Z_{2\ axis}$	180º
	$Z_{3\ axis}$	180º
	$Z_{4\ axis}$	180º
	Vertical stroke	700 mm *(27 9/16")*
Reaction torque		
Maximum torque	Max. vertical work Head	350 Nm *(258 ft lb)*
Load capacity		
	Maximum net load range	0-50Kg *(0-110 lb)*
	Maximum net load	50 kg *(110 lb)*
	Maximum gross load *(load securing device + load to be handled)*	70 kg *(154 lb)*
Pneumatic specifications		
	Power fluid	Pressurised air
	Max. working pressure	0.7 Mpa *(7 bar)*
	Min. working pressure	0.45 Mpa *(4.5 bar)*
	Maximum instant consumption	515 dm^3/min
Operating conditions		
	Temperature[2]	+5 to +50ºC
	Relative humidity	Max. 70%
	Environment	Interior industrial environments
	Noise	<70 dB(A)
	Min. illumination at work station	500 lux

[2] The temperature range will be reduced to +10 to +50°C if suction cups are used on the load-securing device.

4.7.2 Maximum load

The manipulator can support up to 50 kg *(110 lb)* net load and 70 kg *(154 lb)* gross load.

- ✓ **Net load**, refers to the mass of the load you want to work with.
- ✓ **Gross load**, refers to the sum of the net load and the load securing device.

MAXIMUM LOAD

- ✓ The manipulator can carry a net load of up to 50 kg *(110 lb).* (Regardless of the weight of the securing device).

4.7.3 Working pressures

Depending on the working conditions and the mass of the load you wish to work with, you must adjust the supply pressure according to the following table.

WORKING PRESSURE		
Pressure (bar)	Pressure (MPa)	Maximum net load (kg)/(lb)
6	0.6	50 *(110 lb)*
5	0.5	41.6 *(92 lb)*
4	0.4	33.3 *(73 lb)*

Always set 1 bar (0.1 MPa) above the required pressure of the load to be handled to allow for the pressure drop when actuating an actuator and enable the equipment to operate more smoothly.

4.7.4 Pneumatic consumption

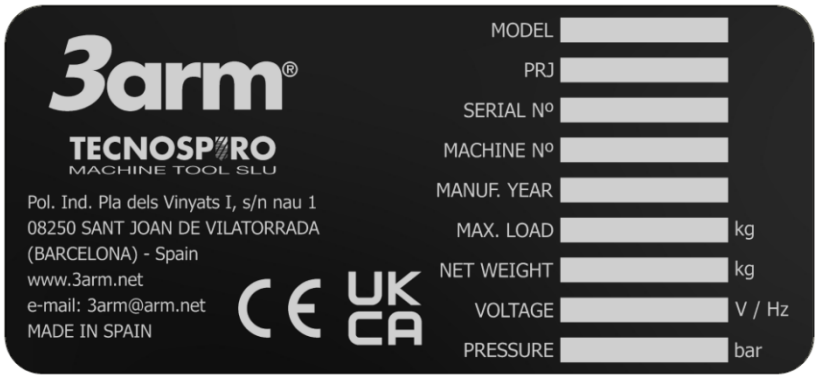
The pneumatic load handling equipment has an associated pneumatic consumption. The following table details the maximum consumption per cycle:

ACTUATORS	MAXIMUM CONSUMPTION PER CYCLE
Main cylinder	4.2 dm^3
Locking cylinders	1 dm^3
Revolving module	4 dm^3
Rotating module	2 dm^3

4.8 IDENTIFICATION

An adhesive in the support structure identifies its manipulator and indicates the following specifications.

CE and UKCA Marking, Manufacturer (name, address and company name), Date of manufacture, Serial number, Model, Maximum working load, Maximum working pressure.

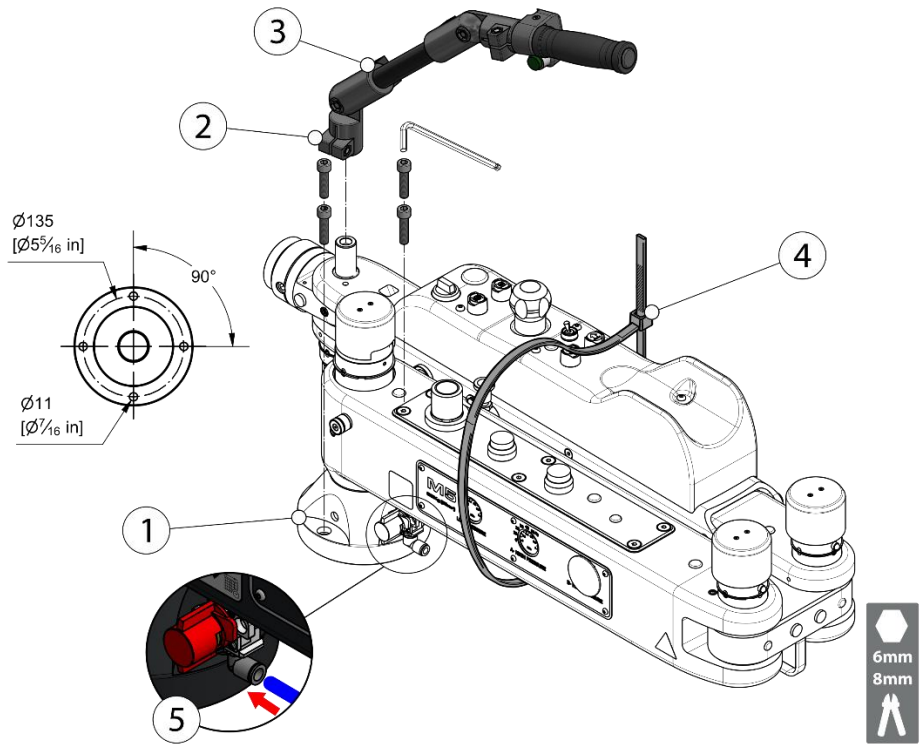


5 INSTALLATION

GENERAL CONSIDERATIONS ABOUT THE INSTALLATION

- ✓ The work bench or installation location must be a horizontal surface, thus avoiding shifts and deviations.
- ✓ The steps to follow for the installation will depend on the fastening method and the alternatives available in the selected location. In any case, the integrator, owner and/or end user is responsible for determining the product's suitability for each use, the installation location, specifically defining the task to be performed within the limits set forth in this manual and the issue of the statement of compliance.
- ✓ ATTENTION! Do not cut the ties, unlock the arm or connect the air intake until the load securing device installation is complete, otherwise the arm could begin a violent upward movement that could cause damage.

1. **Remove the manipulator from its original packaging.**
2. **Secure the base** (1) of the manipulator with four M10 bolts (Recommended torque 45 Nm) *(8 mm Allen key).*
3. **Place the handlebar (3)** on the shaft and tighten the screw (2) (6 mm Allen key).
4. **Install** the load-securing device (if any) and **cut the safety flanges** (4).
5. **Make the air connection** (5) (Ø8 mm tube).
6. **Check that the connection has been made properly** and that there is no risk of leaks or anomalies in the supply.



The surface where the equipment is placed must withstand a minimum torque of 1500 Nm.

INSTALLATION LOCATION

Do not install the equipment in environments such as:

- ✓ areas with explosion or fire hazards
- ✓ exterior areas
- ✓ corrosive areas
- ✓ areas with extreme temperatures (very high or very low)
- ✓ areas with high humidity
- ✓ dusty areas
- ✓ areas with high electromagnetic emissions

SUPPLY AIR

- ✓ The air supply must comply with the specifications shown in [See General Technical Specifications page 17].
- ✓ Use clean air. If the compressed air contains chemicals, organic solvents, synthetic oil or corrosive gases, the parts may be damaged or may cause malfunction.
- ✓ When there is excessive condensation, install a device that removes water, for example, a dryer or water dryer (condensate collector), on the inlet side of the air filter.

ABOUT THE LOAD SECURING DEVICE

- ✓ If the manipulator has an approved load securing device provided by the manufacturer, this may be assembled in the equipment itself, following the recommendations and guidelines in the manual supplied.
- ✓ If the equipment does not have an approved load-securing device, the integrator must attach the assembly/disassembly instructions to this manual.

6 ADJUSTMENTS

GENERAL CONSIDERATIONS ABOUT THE SETTINGS

The settings indicated in this section assume that the manipulator and the corresponding load-mounting device are duly installed and integrated following the guidelines in this manual and, if appropriate, in the manual of the load-mounting device supplied.

6.1 OPENING AND CLOSING THE MAIN VALVE

The main valve allows or restricts the passage of pressurised air to the manipulator.

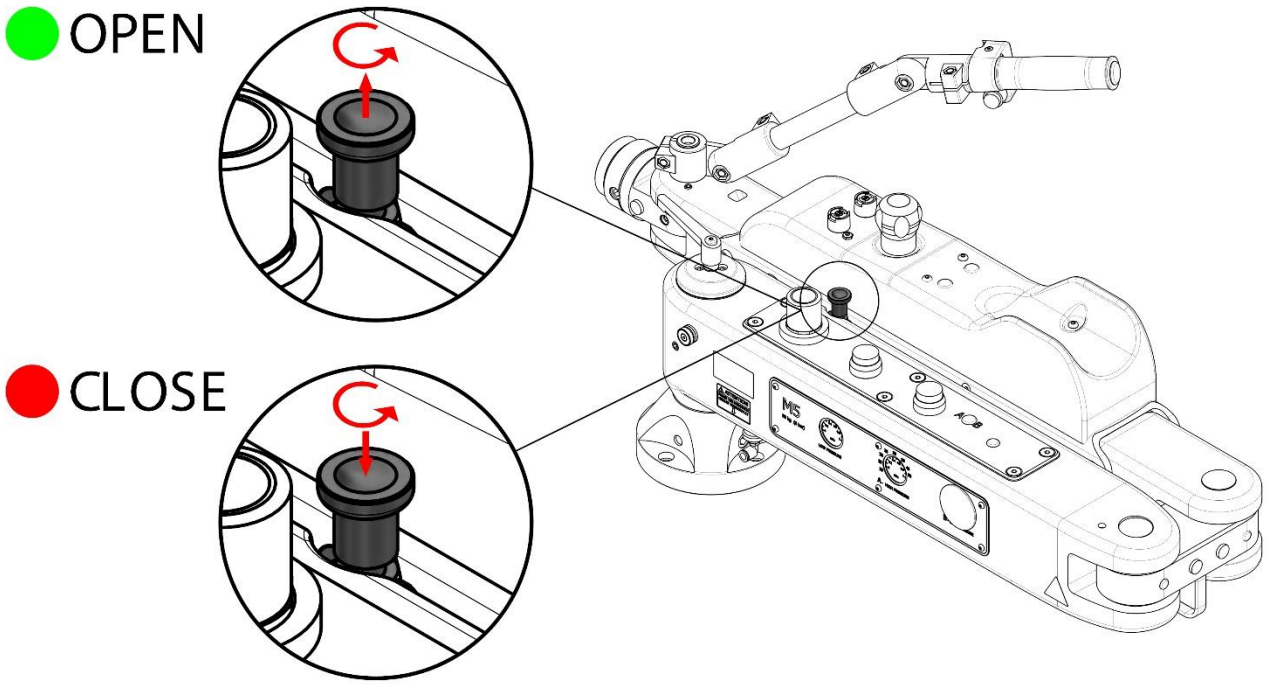
PERIODS OF INACTIVITY

The main valve must restrict the passage of air, closed position (OFF) in periods of inactivity of the equipment.

6.2 PARKING POSITION – WORKING POSITION

Follow these guidelines to bring the M5 Manipulator to the working position:

1. Unlock the locking device: pull the knob upwards and, without letting go, turn slightly counter-clockwise.
2. Accompany the arm away from its initial position.
3. Proceed in reverse order to interlock the locking device.



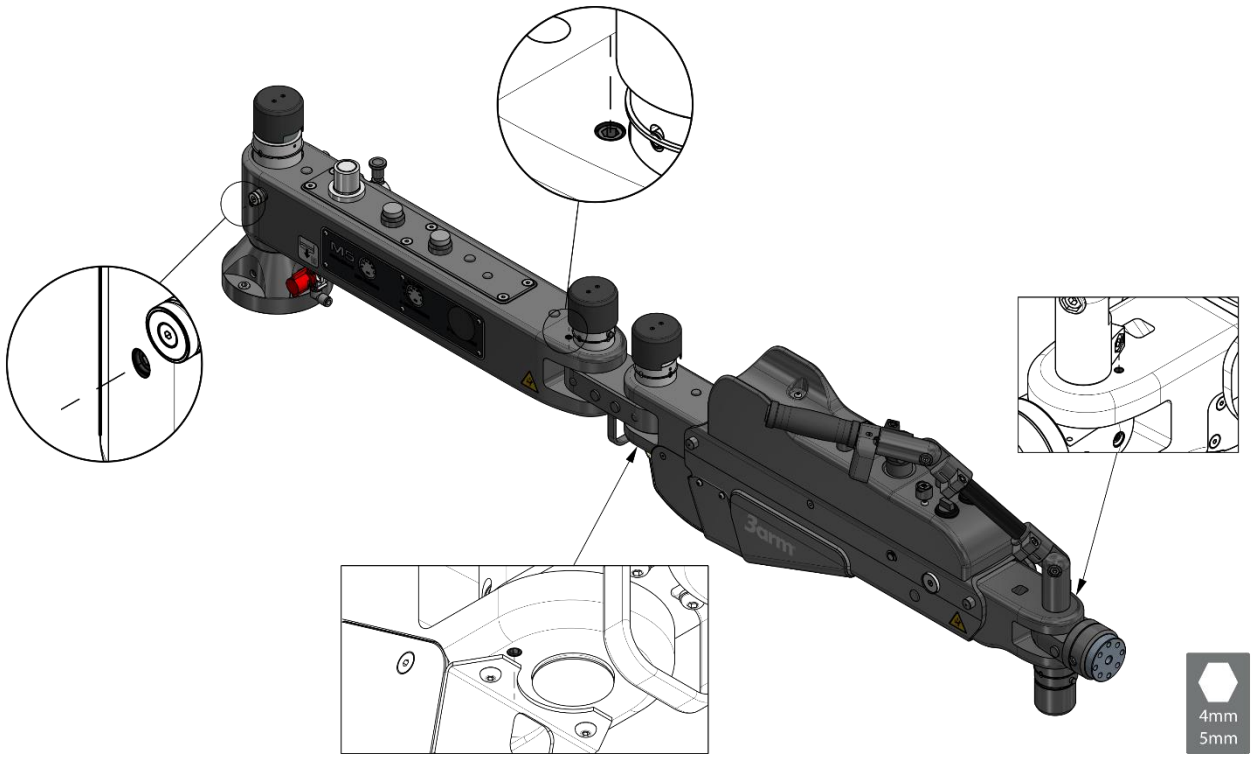
PARKING POSITION

- ✓ When the manipulator is not in use, it must be left in the collected or parking position with the locking device correctly locked.
- ✓ In installation and maintenance tasks and when changing the load securing device, or any other element on the manipulator, position the manipulator in parking mode making sure that the locking device remains correctly locked.
- ✓ Close the main valve while the equipment is not in use.

6.3 REGULATION OF THE RESISTANCE TO ROTATION.

Threaded rods located on the base – parallel, parallel – joint, joint – cross and fork – head enable the rotation of the different axes of the manipulator's movement to be adjusted. The studs can be tightened or loosened to regulate this turning resistance (Allen key 4 and 5 mm).

Regulating the rotating resistance is especially useful in situations where the base of the manipulator is not completely horizontal.



SHIFTING AND DEVIATIONS

Correctly adjusting the regulation of the rotational resistance prevents the risk of shifting and deviations during the operation of the manipulator.

6.4 PRESSURE REGULATION

The objective of this regulation is to maintain the manipulator's tilting arm balanced and therefore ensure the assembly's weightlessness is adapted to the load and working conditions.

There are several workload pressures.

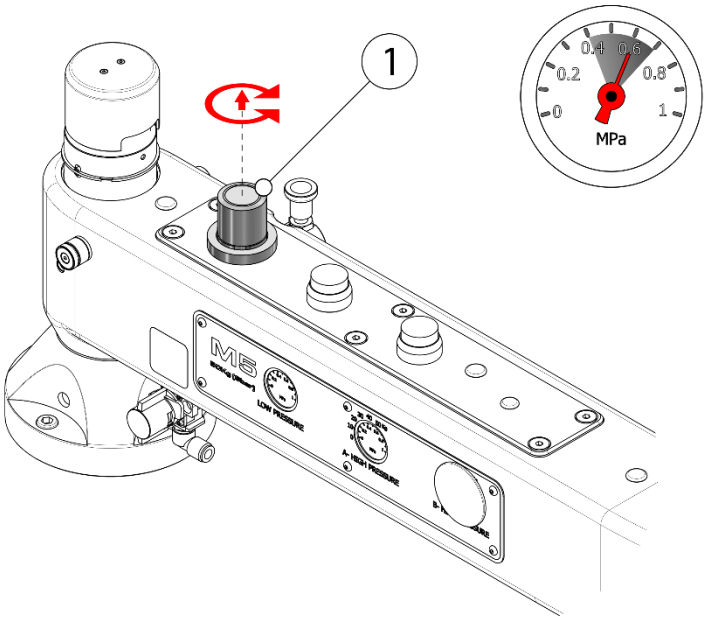
- **Supply pressure:** Pressure of air entering the equipment.
- **Low pressure (LP)** This is the pressure that will reach the cylinder when the manipulator is not carrying a load.
- **High pressure (HP)** This is the pressure that arrives at the cylinder when the manipulator is carrying a load.

These pressures can be easily and safely varied to suit the weight of the load to be handled. Must be adjusted according to the working conditions, following these guidelines:

6.4.1 Regulating the supply pressure

Adjust the air supply pressure according to the working conditions by operating the **pressure regulator R1 (1).**

1. Push up on the knob edge to unlock the anti-rotation mechanism.
2. Turn the knob left or right to adjust the pressure. (max. 0.7 MPa) (Note R1 should be approx. 0.1 Mpa greater than the highest pressure), taking as a reference [SeeWorking pressures page 18].



The minimum supply pressure is 4 bar.

6.4.2 A high pressure

There are two working pressures.

- **Low pressure (R2)** This is the pressure that will reach the cylinder when the manipulator is not carrying a load.
- **High pressure (R3)** This is the pressure that arrives at the cylinder when the manipulator is carrying a load.

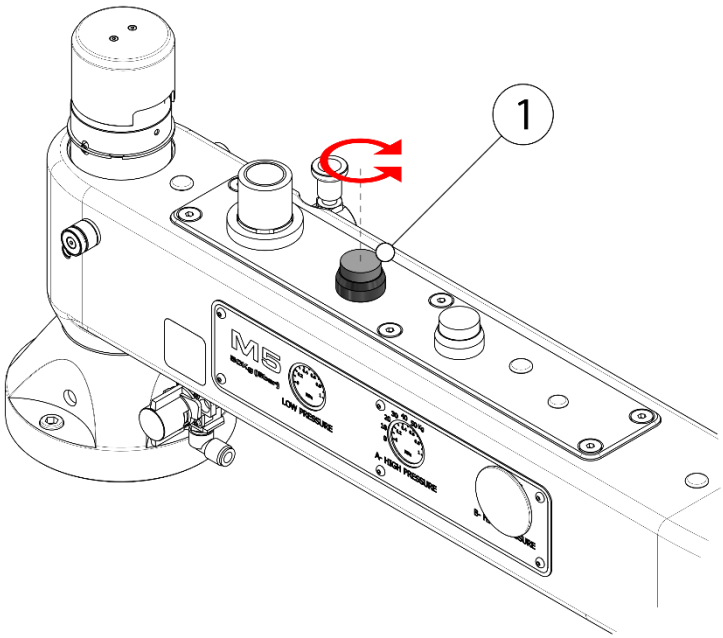
Both pressures must be adjusted according to the working conditions, following these guidelines:

6.4.2.1 Unloaded arm balancing (Low pressure - R2)

CAUTION

- ✓ To regulate the arm at no load, an approved load securing device must be installed and the equipment must be duly integrated.
- ✓ Do not activate high pressure during this process.

1. Ensure that the equipment remains with the low pressure activated [See OPERATIONpage 30].
2. Set the low pressure using the **R2** precision regulator (1) so that the manipulator tilting arm is balanced on its own.

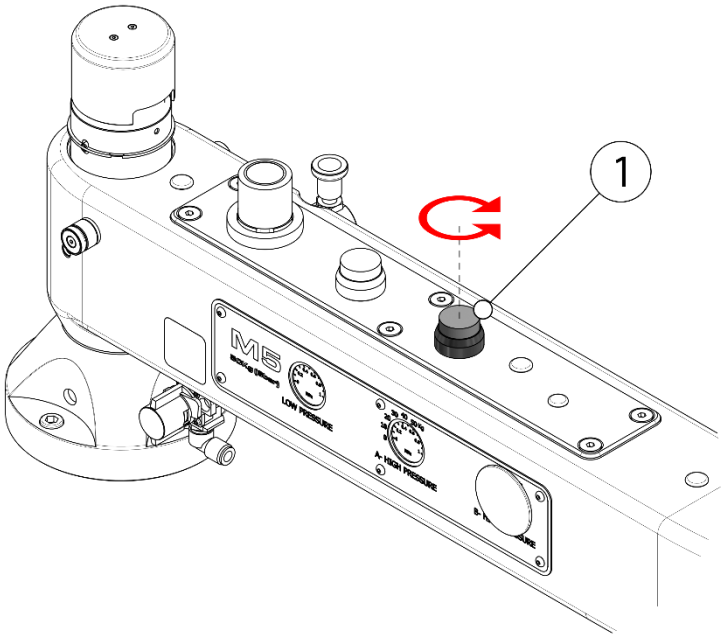


6.4.2.2 *Arm balancing with load (High pressure - R3)*

CAUTION

- ✓ To regulate the arm at load, an approved load securing device must be installed and the equipment must be duly integrated.
- ✓ Refrain from activating high pressure without grip and/or no load.
- ✓ Do not activate low pressure while the manipulator is bearing the load.

1. Ensure that the equipment remains with the high pressure activated [See OPERATION page 30].
2. Set the high pressure using the **R3** precision regulator (1) so that the manipulator tilting arm is balanced on its own.



6.4.3 Two high pressures

There are two working pressures.

- ***Low pressure (R2)*** This is the pressure that arrives at the cylinder when the manipulator is not carrying a load.
- ***High pressure (R3 and R4)*** This is the pressure that arrives at the cylinder when the manipulator is carrying a load.

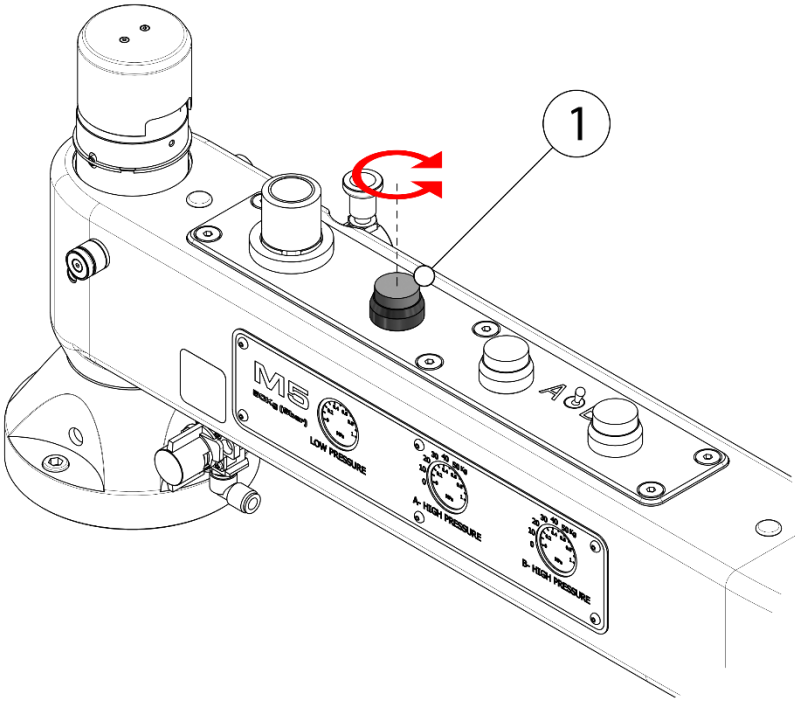
Both pressures must be adjusted according to the working conditions, following these guidelines:

6.4.3.1 Unloaded arm balancing (Low pressure - R2)

CAUTION

- ✓ To regulate the arm at no load, an approved load securing device must be installed and the equipment must be duly integrated.
- ✓ Do not activate high pressure during this process.

1. Ensure that the equipment remains with the low pressure activated [See OPERATION page 30].
2. Set the low pressure using the **R2** precision regulator (1) so that the manipulator tilting arm is balanced on its own.

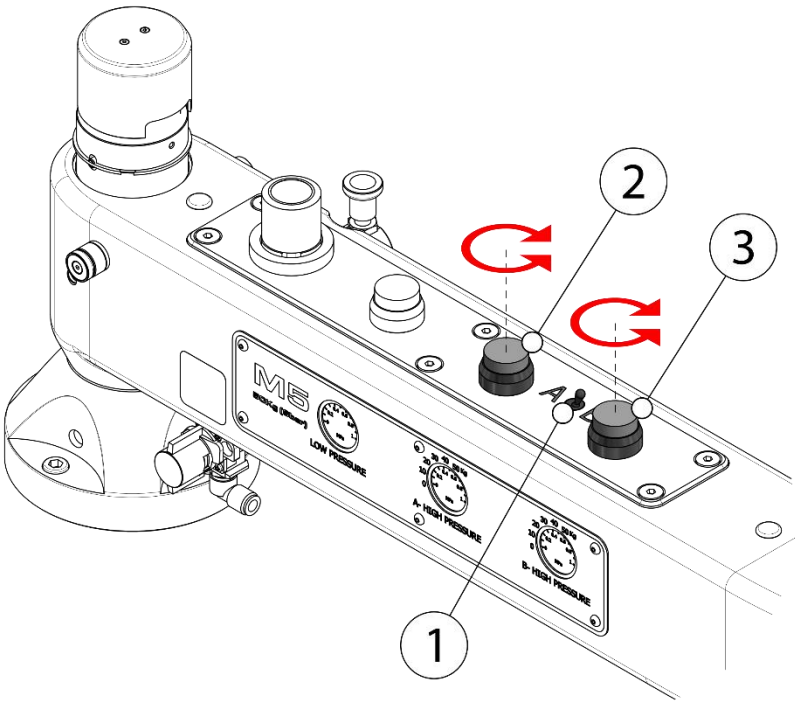


6.4.3.2 *Arm balancing with load (High pressure - R3 and R4)*

CAUTION

- ✓ To regulate the arm at load, an approved load securing device must be installed and the equipment must be duly integrated.
- ✓ Refrain from activating high pressure without grip and/or no load.
- ✓ Do not activate low pressure while the manipulator is bearing the load.

1. Ensure that the equipment remains with the high pressure activated [See OPERATION page 30].
2. Set the switch (1) to (A).
3. Set the high pressure using the **R3** precision regulator (2) so that the manipulator tilting arm is balanced on its own.
4. Leave the piece and activate the low pressure. Set the switch (1) to (B).
5. Take the next piece and activate the high pressure.
6. Adjust the high pressure using the **R4** precision regulator (3) so that the manipulator tilting arm balances on its own.



7 OPERATION

The manipulator is designed to handle loads manually.

Although the handling of the load is manual, the pneumatic action helps to grip, orientate and support the load.

INTEGRATION

This manipulator requires a load-securing device to perform a given application. It is the responsibility of the integrator to study, design and validate the load-mounting device depending on the application. This device must be authorised by the manufacturer of the manipulator.

This chapter must be complemented with the corresponding section on the operation of the load-mounting device selected.

OPERATION

The equipment must only be used after correct integration and after correctly installing the load securing device.

7.1 SINGLE HANDLEBAR

Operation valid for 1 high pressure and 2 high pressure configurations.

OPERATION

- The following information regarding the operation of the M5 Manipulator is informative. The equipment must only be used after correct integration and after correctly installing the load securing device.
- Do not activate the high pressure without a load-mounting device duly installed and integrated.

All the actuators on the [3]equipment must remain locked to prevent unintentional activation.

To **activate the high pressure**:

1. Bi-manual safety system, press and hold button (1) and then press the button (2). The air flow to the actuator will be enabled and this will then be able to carry out its function.
2. Bi-manual safety system, press and hold button (1) and then press the button (2). High pressure is activated.

NOTE: It is possible to perform both tasks (activate the actuators and the high pressure) in one step. To do so, press and hold the buttons (1 and 2) for a few additional seconds.

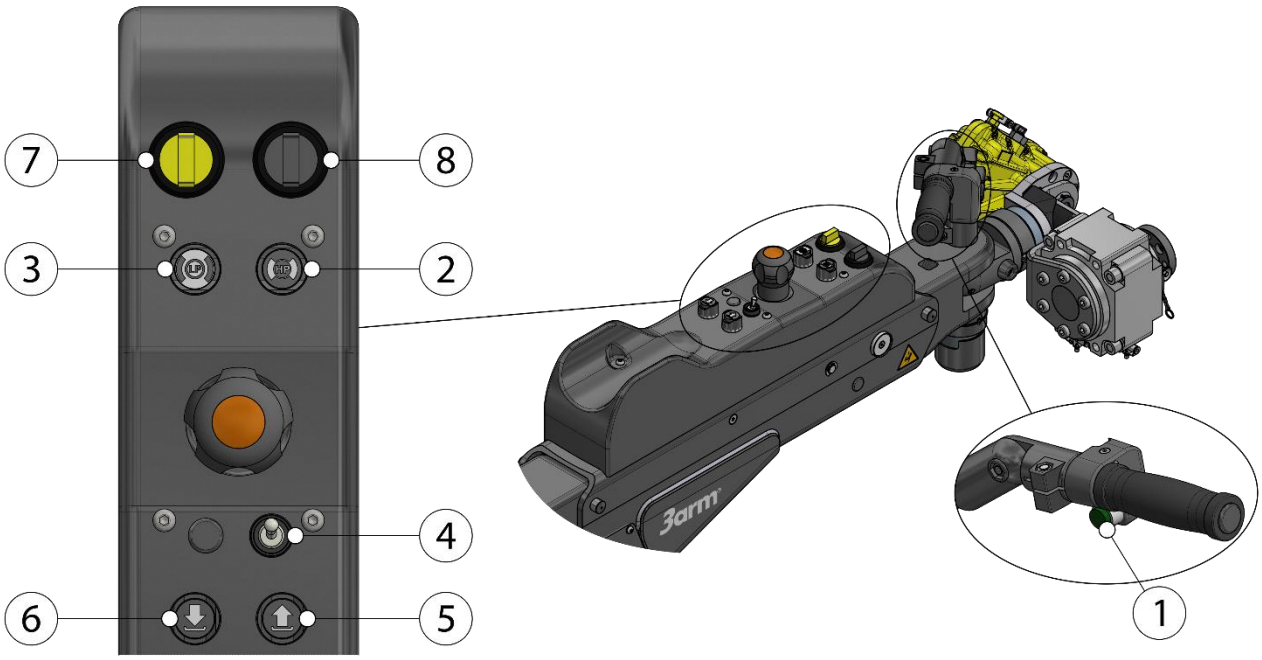
To **activate the low** pressure:

1. Bi-manual safety system, press and hold button (1) and then press the button (3). The low pressure is activated.
2. Bi-manual safety system, press and hold button (1) and then press the button (3). The air flow to the actuator is allowed to deactivate it.

NOTE: It is possible to carry out both tasks (low pressure activation and deactivation of actuators) in a single step; to do this, press and hold the buttons (1 and 3) for a few additional seconds.

If the manipulator is purchased together with a suitable securing device, the complete operating cycle can be found in the appendix for the corresponding securing device.

[3] Actuators of the Manipulator: Opening/closing clamp or securing device, transition from low to high pressure or vice versa, up/down movement of the lifting accessories, movement of the rotation modules or Revolving module.



IDENT	ACTUATOR
1	ENABLING MECHANISM/SAFETY SYSTEM
2	CLOSE MOUNTING DEVICE + HIGH PRESSURE
3	LOW PRESSURE + OPEN MOUNTING DEVICE
4*	PNEUMATIC MANIPULATOR LOCK
5*	RAISE PNEUMATIC LIFT/COLUMN D100
6*	LOWER PNEUMATIC LIFT/COLUMN D100
7*	REVOLVING ACTUATOR ACTIVATION
8*	ROTATING ACTUATOR ACTIVATION

***Optional**

ADDITIONAL INFORMATION

Only for equipment with a lift.

To **raise the manipulator** you must:

Bi-manual safety system, press button (1) and, without releasing it, press button (6). The set will rise.

To **raise the manipulator** you must:

Bi-manual safety system, press and hold button (1) and then press the button (6). The assembly will be lowered.

ADDITIONAL INFORMATION

Only for equipment with a pneumatic lock.

To block **the manipulator:**

Press the switch (4). The pneumatic lock of the manipulator will be activated.

7.2 DOUBLE HANDLEBAR

Operation valid for 1 high pressure and 2 high pressure configurations.

OPERATION

- The following information regarding the operation of the M5 Manipulator is informative. The equipment must only be used after correct integration and after correctly installing the load securing device.
- Do not activate the high pressure without a load-mounting device duly installed and integrated.

All the actuators on the [4]equipment must remain locked to prevent unintentional activation.

To **activate the high pressure**:

1. Bi-manual safety system, press and hold button (1) and then press the button (2). The air flow to the actuator will be enabled and this will then be able to carry out its function.
2. Bi-manual safety system, press and hold button (1) and then press the button (2). High pressure is activated.

NOTE: It is possible to perform both tasks (activate the actuators and activate the high pressure) in a single step. To do so, press and hold the button (1 and 2) a few additional seconds.

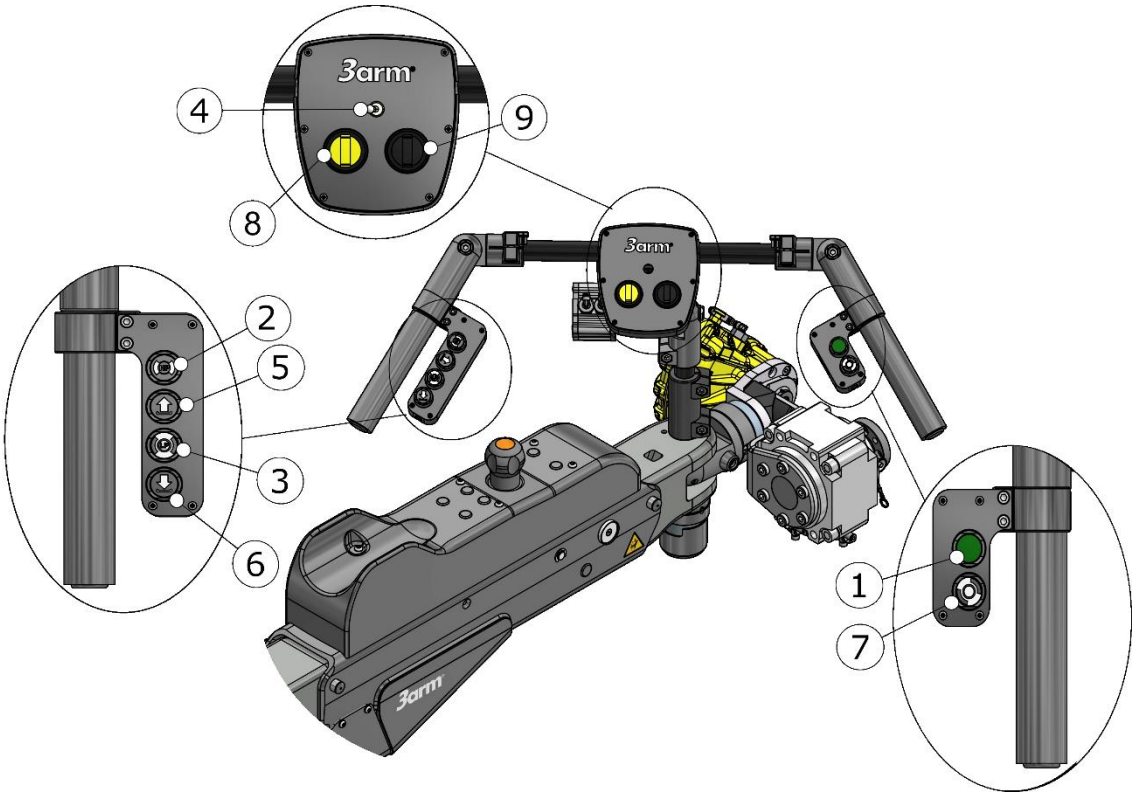
To **activate the low** pressure:

1. Bi-manual safety system, press and hold button (1) and then press the button (3). The low pressure is activated.
2. Bi-manual safety system, press and hold button (1) and then press the button (3). The air flow to the actuator is allowed to deactivate it.

NOTE: It is possible to perform both tasks (activate the low pressure and deactivate actuators) in a single step; to do this, press and hold the button (1 and 3) a few additional seconds.

If the manipulator is purchased together with a suitable securing device, the complete operating cycle can be found in the appendix for the corresponding securing device.

[4] Actuators of the Manipulator: Opening/closing clamp or securing device, transition from low to high pressure or vice versa, up/down movement of the lifting accessories, movement of the rotation modules or Revolving module.



*Lift controls (5) and (6) are only on the handlebar or cover

IDENT	ACTUATOR
1	ENABLING MECHANISM/SAFETY SYSTEM
2	CLOSE MOUNTING DEVICE + HIGH PRESSURE
3	LOW PRESSURE + OPEN MOUNTING DEVICE
4*	PNEUMATIC MANIPULATOR LOCK
5*	RAISE PNEUMATIC LIFT/COLUMN D100
6*	LOWER PNEUMATIC LIFT/COLUMN D100
7*	PNEUMATIC HANDLEBAR LOCK
8*	REVOLVING ACTUATOR ACTIVATION
9*	ROTATING ACTUATOR ACTIVATION

***Optional**

ⓘ ADDITIONAL INFORMATION

Only for equipment with a lift.

To **raise the manipulator** you must:

Bi-manual safety system, press button (1) and, without releasing it, press button (6). The set will rise.

To **raise the manipulator** you must:

Bi-manual safety system, press and hold button (1) and then press the button (6). The assembly will be lowered.

ⓘ ADDITIONAL INFORMATION

Only for equipment with a pneumatic lock.

To block the manipulator:

Press the switch (4). The pneumatic lock of the manipulator will be activated.

ⓘ ADDITIONAL INFORMATION

Only for equipment with a pneumatic lock on the handlebar.

To lock the handlebar:

Bi-manual safety system, press and hold button (1) and then press the button (7). This activates the pneumatic lock of the handlebar and locks it.

7.3 VERTICAL HANDLEBAR

This handlebar is specially designed for fast and dynamic pick and place applications, using suction cup or magnet-type actuators. In the case of applications with grippers, a bi-control button is added for the user's safety.

OPERATION

The following information regarding the operation of the M5 Manipulator is informative. The equipment must only be used after correct integration and after correctly installing the load securing device.

The handle remains locked by default to prevent accidental activation of the high/low pressure, or opening of the grippers or mounting devices.

To **activate the high pressure**:

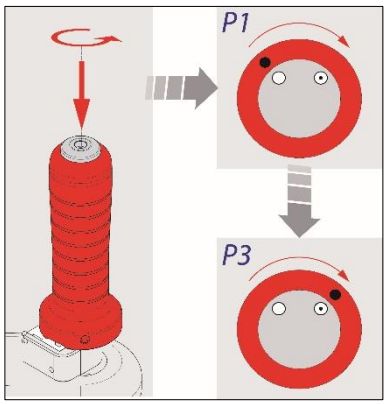
1. Press the centre button of the handle and, without releasing it, turn it clockwise. The load securing device, e.g. a suction cup, will close its grip.
2. Then the high pressure will be activated (High pressure - P3 ⊙)

To **activate the low** pressure:

1. Press the centre button of the handle and, without releasing it, turn it counter clockwise. Low pressure is activated (Low pressure – P1 ○).
2. Then the load securing device, for example a suction cup, will open its grips.

OPERATING THE HANDLE
(Option for manipulators without handlebar and/or vertical movement)

- ✓ If the handle is positioned at P3, and the pressure gauge of the regulator (R3) shows pressure without the manipulator supporting the load, there is a danger of the arm starting to move upwards suddenly.
- ✓ Refrain from positioning the grip on P3, with no grip and no load.
- ✓ Do not position the grip on P1 while the manipulator is loaded.



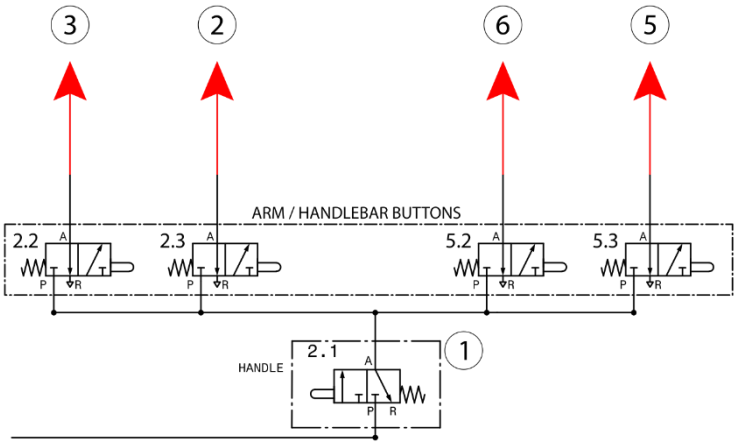
8 SAFETY DEVICES

8.1 BI-MANUAL SYSTEM

With single or double handlebar any of the movements commanded by the buttons (2.2, 2.3, 5.2 and 5.3) will be blocked by default. **Enabling is only possible if the safety button (2.1) is pressed and held beforehand.**

The operating mode will then be as follows:

Press and hold the two-hand safety button (2.1) and, without releasing it, press the buttons (2.2, 2.3, 5.2 and 5.3) as required [See OPERATION page 30].



VERIFICATION

✓ Its correct operation must be checked as detailed below and at the periods indicated in the maintenance programme [See MAINTENANCE PROGRAMME page 43].

1- Move the arm to its retracted or parking position [See PARKING POSITION – WORKING POSITION page 23].
2- Open the main valve (ON position) [See OPENING AND CLOSING THE MAIN VALVE page 22].
3- Check that the buttons on the control cover are not operational.
4- Press and hold the two-hand safety button (2.1) and, without releasing it, press the buttons (2.2, 2.3, 5.2 and 5.3) as required [See OPERATION page 30] to check its correct functioning.

CAUTION

Before checking, it is be a good idea to set the supply pressure R1 so that the parking system does not receive the stress of activating the high pressure [See Regulating the supply pressure page 25].

8.2 COMBINED USE OF BUTTON AND HANDLE

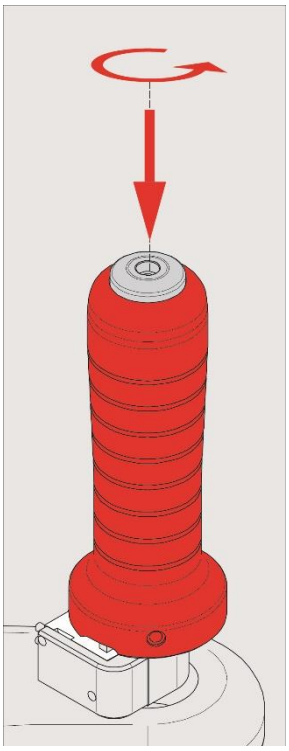
OPERATION

✓ The following information regarding the operation of the M5 Manipulator is informative. The equipment must only be used after correct integration and after correctly installing the load securing device.

This safety device locks the rotation of the vertical handlebar grip *(the functions: opening and closing the load securing device and adjusting the pneumatic cylinder are locked).*

To unlock, the operator must press the central button and, without releasing it, turn the handle in the appropriate direction. [See VERTICAL HANDLEBAR page 36].

This device prevents the suspended load from being released by an involuntary or accidental action.



VERIFICATION

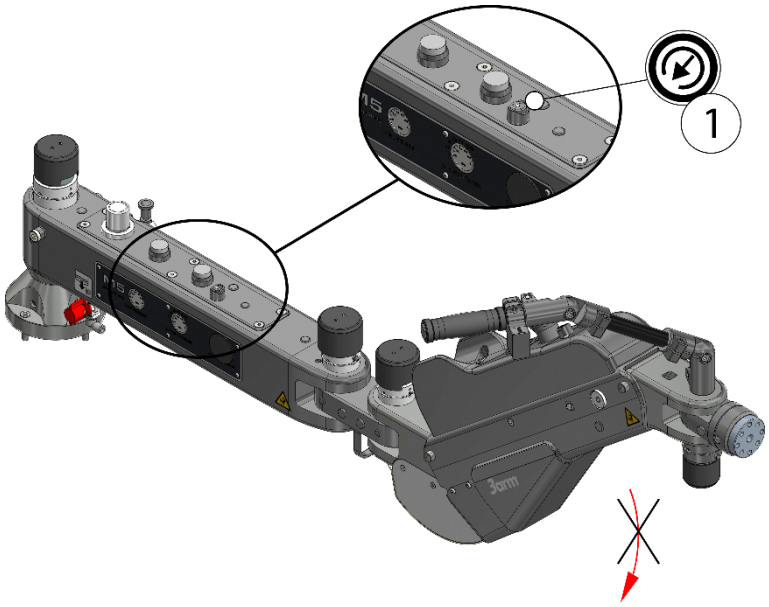
✓ Its correct operation must be checked as detailed below and at the periods indicated in the maintenance programme [See MAINTENANCE PROGRAMME page 43].

1. Move the arm to its retracted or parking position [See PARKING POSITION – WORKING POSITION page 23].
2. Open the main valve (ON position) [See OPENING AND CLOSING THE MAIN VALVE page 22].
3. Turn the handle grip without pressing the central button. The handle (red part in the image) will remain locked.
4. Press and hold the central button and turn the handle (red part in the image).

8.3 LOCKING THE ARM'S SWIVEL MOTION

In the event of sudden failure of the pneumatic power supply, a safety system will lock the arm, preventing uncontrolled and sudden descent.

If necessary after the power supply failure, there is button (1) on the radial arm to release the cylinder pressure and allow the arm to lower in a controlled manner.



VERIFICATION

- ✓ Its correct operation must be checked as detailed below and at the periods indicated in the maintenance programme. [See MAINTENANCE PROGRAMME page 43].
- ✓ To ensure this verification is effective, an approved load securing device must be installed next to the manipulator.

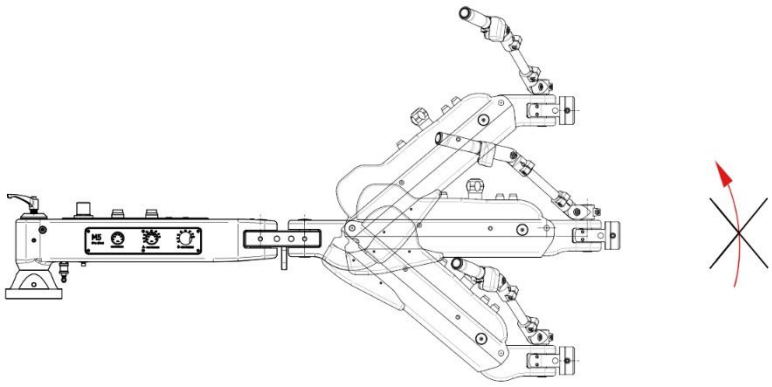
Steps for verification:

1. Open the main valve (ON position) and check the air supply [SeeOPENING AND CLOSING THE MAIN VALVE page 22].
2. Activate high pressure in the equipment [See OPERATION page 30].
3. Close the main valve (OFF position) [See OPENING AND CLOSING THE MAIN VALVE page 22].

The swivel arm must remain still or be lowered slightly after the air supply is cut off.

8.4 SAFETY VALVE IN THE ACTUATOR TO ENSURE THE PART IS CLAMPED CORRECTLY (OPTIONAL)

If the part to be manipulated is incorrectly clamped and an attempt is made to activate high pressure, it will not be activated, thus avoiding uncontrolled and sudden ascent.



VERIFICATION

- ✓ Its correct operation must be checked as detailed below and at the periods indicated in the maintenance programme. [See MAINTENANCE PROGRAMME page 43].
- ✓ To ensure this verification is effective, an approved load securing device must be installed next to the manipulator.

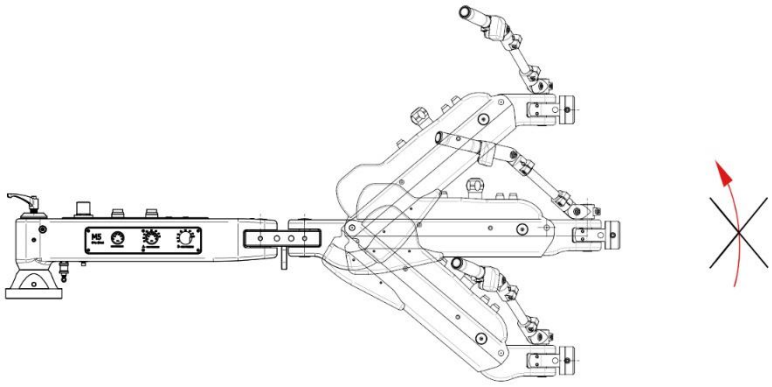
Steps for verification:

1. Open the main valve (ON position) and check the air supply [SeeOPENING AND CLOSING THE MAIN VALVE page 22].
2. Activate the actuator with the part to be clamped. [See OPERATION page 30].
3. Check that the safety valve located on the actuator is correctly activated, which indicates that the part is clamped correctly.
4. Disable the actuator [See OPERATION page 30].

8.5 LOW PRESSURE ACTIVATION IN CASE OF LOSS OF CORRECT ACTUATOR CLAMPING SIGNAL

Valid if there is a safety valve for correct clamping.

In case of sudden failure of securing the part to be manipulated, low pressure is automatically activated, thus avoiding uncontrolled and sudden rise.



VERIFICATION

- ✓ Its correct operation must be checked as detailed below and at the periods indicated in the maintenance programme. [See MAINTENANCE PROGRAMME page 43].
- ✓ To ensure this verification is effective, an approved load securing device must be installed next to the manipulator.
- ✓ If necessary, have two operators to carry out this task with total safety.

Steps for verification:

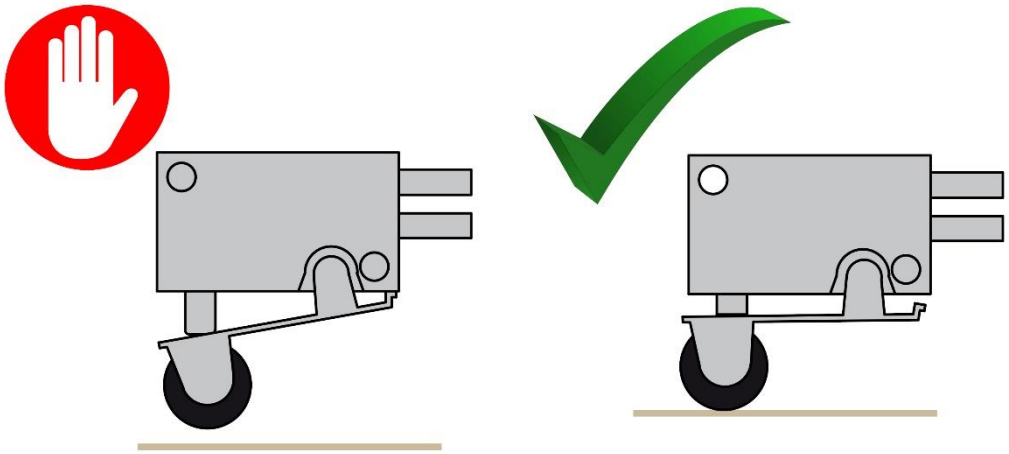
1. Open the main valve (ON position) and check the air supply [SeeOPENING AND CLOSING THE MAIN VALVE page 22].
2. Adjust the high pressure with the regulator R3 to 1 bar above the pressure of the regulator R2.
3. Activate the actuator without any part to be clamped. [See OPERATION page 30].
4. Activate the safety valve located on the actuator and that indicates the correct clamping of the part.
5. Activate high pressure on the equipment. CAUTION: when activating high pressure, the arm will ascend with a force of 5 kg [See OPERATION page 30].
6. Stop operating the safety valve and check that the arm drops; that is, that low pressure is activated.

The swivel arm must remain with low pressure activated.

8.6 SAFETY MICRO

If the safety micro notes the presence of the part to be manipulated, this will give the signal so the high pressure can be enabled. If it does not note the presence of the part, it will not give permission to activate the high pressure, thus preventing the sudden, uncontrolled elevation of the arm.

If with the part already secured and the high pressure activated the safety micro stops perceiving the presence of the part being manipulated, the low pressure will be activated to prevent the sudden, uncontrolled elevation of the arm.



8.7 VACUUM SWITCH

If the vacuum pressure switch detects a correct vacuum level it will give the signal to activate the high pressure and make it possible to take the workpiece. If the correct vacuum level is not detected, it will not be possible to enable the high pressure, thus preventing the sudden, uncontrolled elevation of the arm.

9 PNEUMATIC DIAGRAM

Consult the pneumatic diagram corresponding to the chosen configuration with the documentation supplied with your Manipulator.

10 MAINTENANCE

10.1 MAINTENANCE PROGRAMME

DESCRIPTION ELEMENT	ACTION / PERIOD	PERIOD
Regulator filter (air group)	Look for breaks, scratches or any deterioration of the transparent resin vessel on the air filter, regulator.	Periodically
	Replace the filter cartridge.	Every two years or when the pressure drop is 0.1 MPa, whichever comes first.
Bi-manual control (Single and double handlebar)	Checking the correct use of the handle-knob system according to [See BI-MANUAL SYSTEM page 37].	Before each use
Bi-manual control (Vertical Handlebar)	Checking the correct use of the handle-knob system according to [See COMBINED USE OF BUTTON AND HANDLE page 38].	Before each use
Crankpin CR (mounted on the head CB5, CF5 and CI5)	Rubber components such as gaskets are considered consumables and their condition must be checked every year and replaced every three years. [See CHECKING THE JOINTS page 55]. 	Yearly/every three years
Pneumatic circuit	Check its proper functioning, in particular the safety systems according to [See PNEUMATIC DIAGRAM page 43].	Before each use
Screws and fasteners	Check tightening and functionality of the securing elements.	Periodically
Drain filter regulator	Purge the air filter belonging to the filter regulator assembly.	Periodically
General cleaning	When dirty, clean with a mild household product. Do not use other cleaning agents, as they may cause damage.	Periodically
General check of the pneumatic connections	Carry out a general check of the pneumatic connections. [See PNEUMATIC DIAGRAM page 43].	Periodically
Gas spring	Check its correct operation and, if necessary, replace it [See REPLACING THE CYLINDER AND THE GAS SPRING page 45].	Before each use

10.2 COMPRESSED AIR MAINTENANCE UNIT

For good functioning of the compressed air unit, an air quality level of class 1.4.1 is recommended, according to the table attached. ISO 8573-1 2010.

ISO 8573-1:2010 CLASS	PARTICLES				WATER		OIL
	Maximum number of particles of the following size [µm]/m³ of compressed air			Mass Concentration	Vapour Pressure Dewpoint	Content of liquid	Total content (liquid, aerosol, gas)
	0.1 - 0.5 µm	0.5 - 1 µm	1 - 5 µm	[mg/m³]	[°C]	[g/m³]	[mg/m³]
0	By definition of the user, less contamination than class 1						
1	≤ 20000	≤ 400	≤ 10	-	≤ -70	-	≤ 0.01
2	≤ 400000	≤ 6000	≤ 100	-	≤ -40	-	≤ 0.1
3	-	≤ 90000	≤ 1000	-	≤ -20	-	≤ 1
4	-	-	≤ 10000	-	≤ +3	-	≤ 5
5	-	-	≤ 100000	-	≤ +7	-	-
6	-	-	-	≤ 5	≤ +10	-	-
7	-	-	-	5 - 10	-	≤ 0.5	-
8	-	-	-	-	-	0.5 - 5	-
9	-	-	-	-	-	5 - 10	-
X	-	-	-	> 10	-	> 10	> 5

Periodically check the water level accumulated in the reservoir, and bleed if it has reached the limit.

10.3 PNEUMATIC LOCKING BRAKES

It is advisable to revise the functioning of the locking brakes periodically.
The frequency of this revision will, in each case, depend on the number of cycles carried out with them. It is recommended that correct operation is checked every 6 months. To check, adjust or replace [See PNEUMATIC LOCKS page 48].
The stroke of the locking brake actuators is 1.2 mm.

CAUTION

Do not operate the pneumatic locking brakes when disassembled, or when empty (disassembled assemblies), as this will damage the mechanism.

10.4 CHECKING THE GAS SPRING OPERATION

To check that the gas spring is working correctly:

- ✓ Adjust the ***pressure regulator R2 to between 0 - 0.3 MPa***[5] [See PRESSURE REGULATION page 48].
- ✓ Check that the ***arm is able to stay balanced in a horizontal position within the indicated pressure range.***

[5] If the tooling assembly exceeds the load that the shock absorbers can withstand (20 kg) the 0.3 MPa must be exceeded. Because the additional load that the gas springs cannot support is supplied by removing load range from the main cylinder.

10.5 REPLACING THE CYLINDER AND THE GAS SPRING

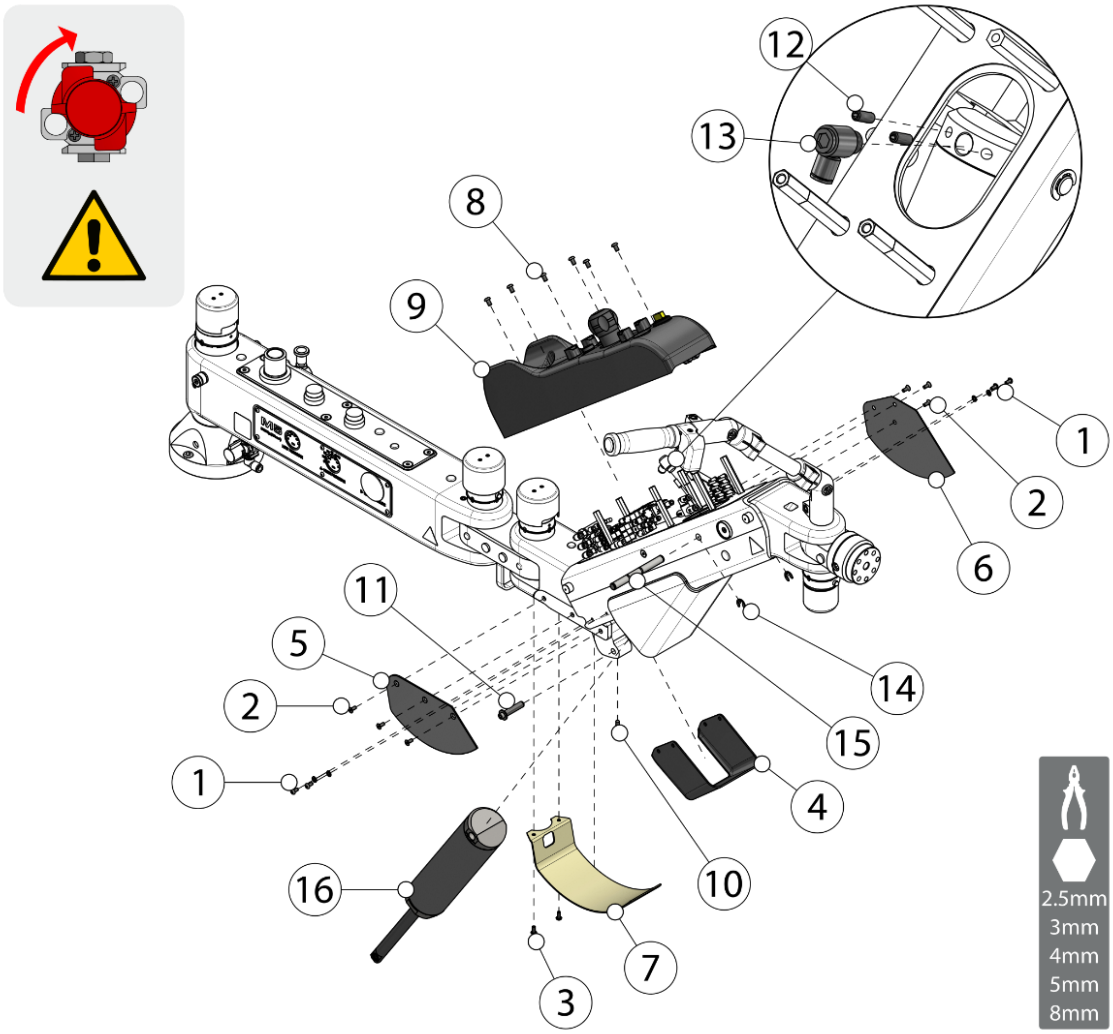
BEFORE REPLACING THE GAS SPRING

- ✓ The equipment must be duly installed and integrated.
- ✓ Disconnect the pneumatic supply from the equipment [See OPENING AND CLOSING THE MAIN VALVEpage 22].
- ✓ It is advisable to dedicate two operators to this task.

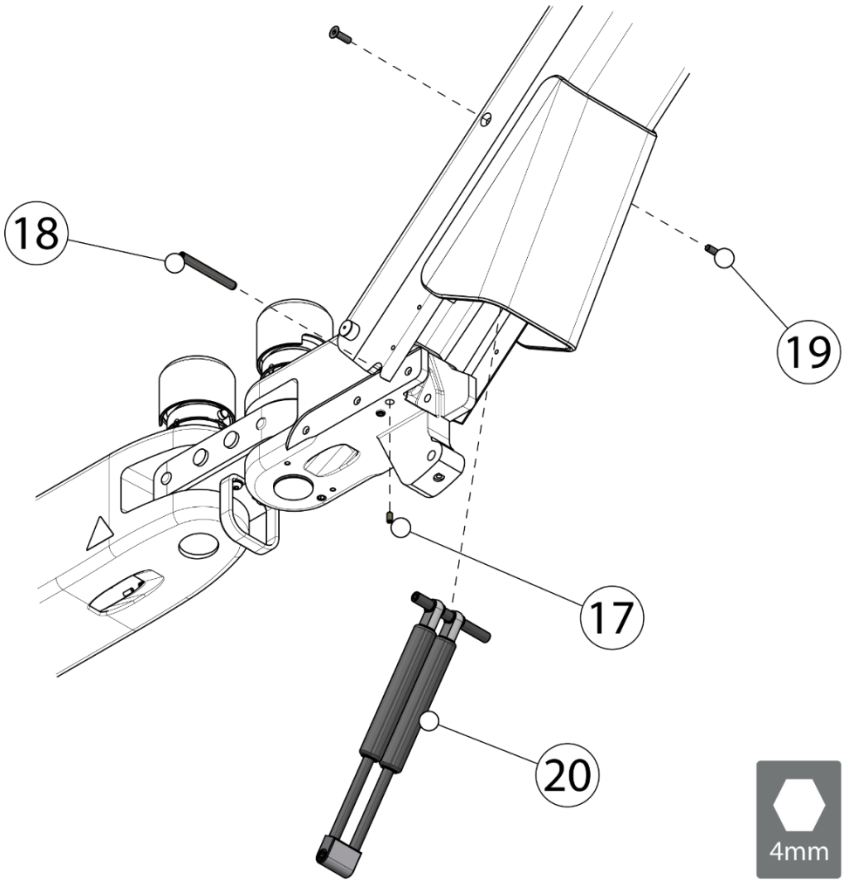
1. Swivel the arm to its highest position.

KEEP THE ARM IN THAT POSITION

2. Remove the screws (1, 2, 3) (3 mm Allen key) and remove the covers (4, 5, 6, 7).
3. Remove the screws (8) (4 mm Allen key) and remove the control cover (9) taking care not to pinch any tubes or cables.
4. Loosen the stud (10) (3 mm Allen key) and remove the circlip (11).
5. Loosen the stud (12) (3 mm Allen key) and the coupling (13) (8 mm Allen key).
6. Remove the safety washers (14) and take out the cylinder shaft (15).
7. The cylinder (16) will be free, you can remove it and replace it with the new one.



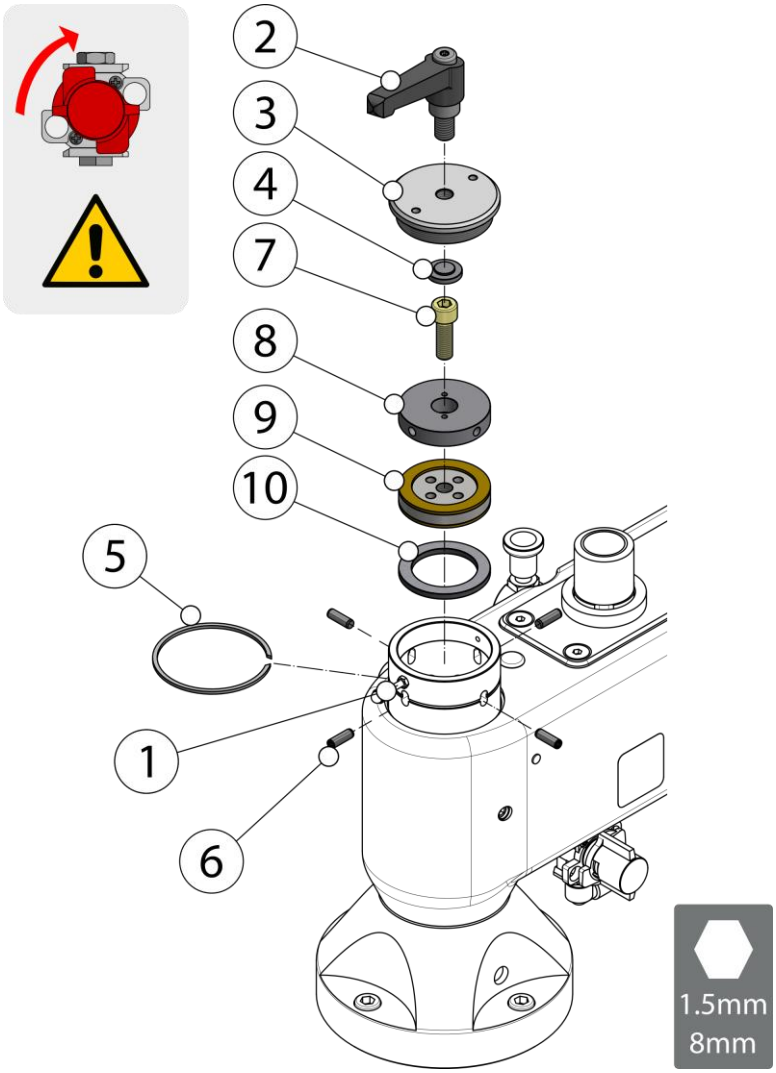
8. Loosen the stud (17) (2.5 mm Allen key) and remove the shaft (18) (M5 extractor).
9. Remove the screws (19) (4 mm Allen key) the shock absorber (20) will be free, you can remove it and replace it with the new one.
10. Proceed in reverse order for assembly.



10.6 REPLACING RADIAL PADS L11

Operation valid for any manual locking (except tilting).

1- Release the air pressure of the arm.
2- Loosen the stud (1) (1.5mm Allen key).
3- Remove the handle (2), the cover (3) and the pusher (4).
4- Remove the safety ring (5) and use an M4 extractor to remove the pins (6).
5- Remove the screw (7)[6] (8 mm Allen key) remove the cylindrical pusher (8) and use an M12[7] extractor to take out the brake assembly with the pads (9) and remove the brake disc (10).
6- Replace pieces (8) (9) and (10).
7- Proceed in reverse order for assembly and verify the functioning of the lock again.

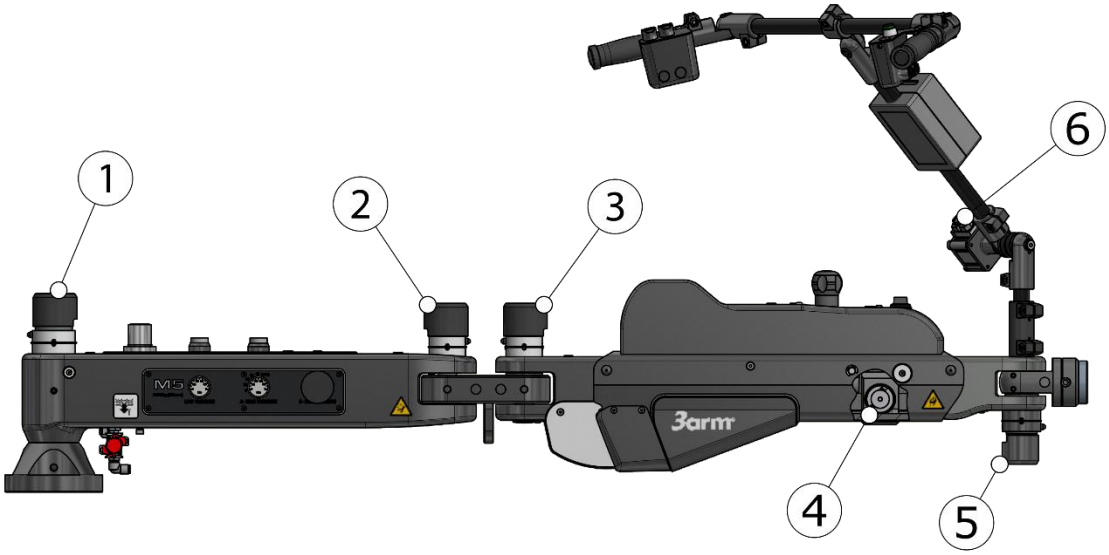


[6] For the joint locks will need a 7mm Allen Key and for the headmember a 6mm
[7] For the joint locks will need an M10 extractor and for the headmember a M8.

10.7 PNEUMATIC LOCKS

If the manipulator's pneumatic locks malfunction, follow these check points.

10.7.1 PNEUMATIC LOCKS: IDENTIFICATION



1- Base radial lock
2- Front joint radial lock
3- Rear joint radial lock
4- Arm tilting lock
5- Head radial lock
6- Handlebar lock

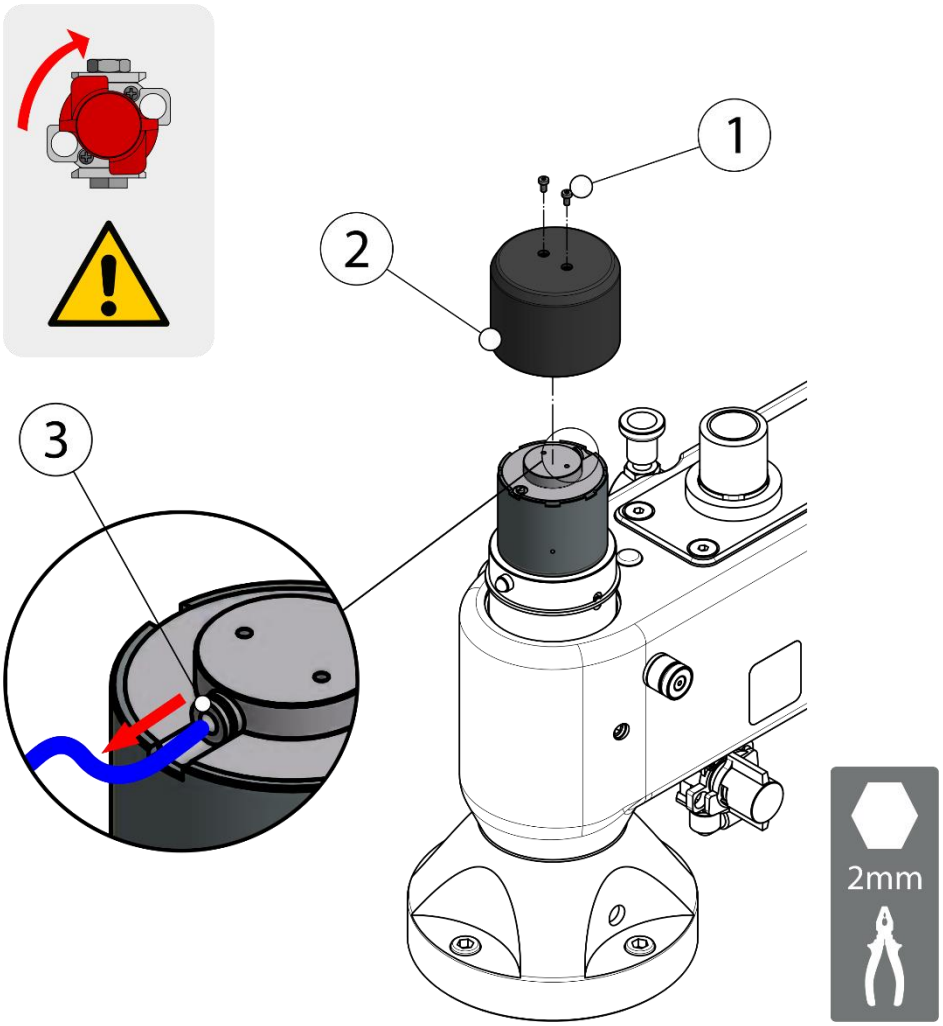
10.7.2 CHECKING THE AIR SUPPLY

Operation valid for any radial locking cylinder.

To perform this check:

1. Release the air pressure of the arm.
2. Remove the screws (1) (2mm Allen key) and remove the cap (2).
3. Disconnect the air supply tube from the coupling (3) that supplies the cylinder.
4. Allow the air to pass and activate the lock in question, checking that air flows through the tube.
5. Proceed in reverse order for assembly and verify the functioning of the lock again.

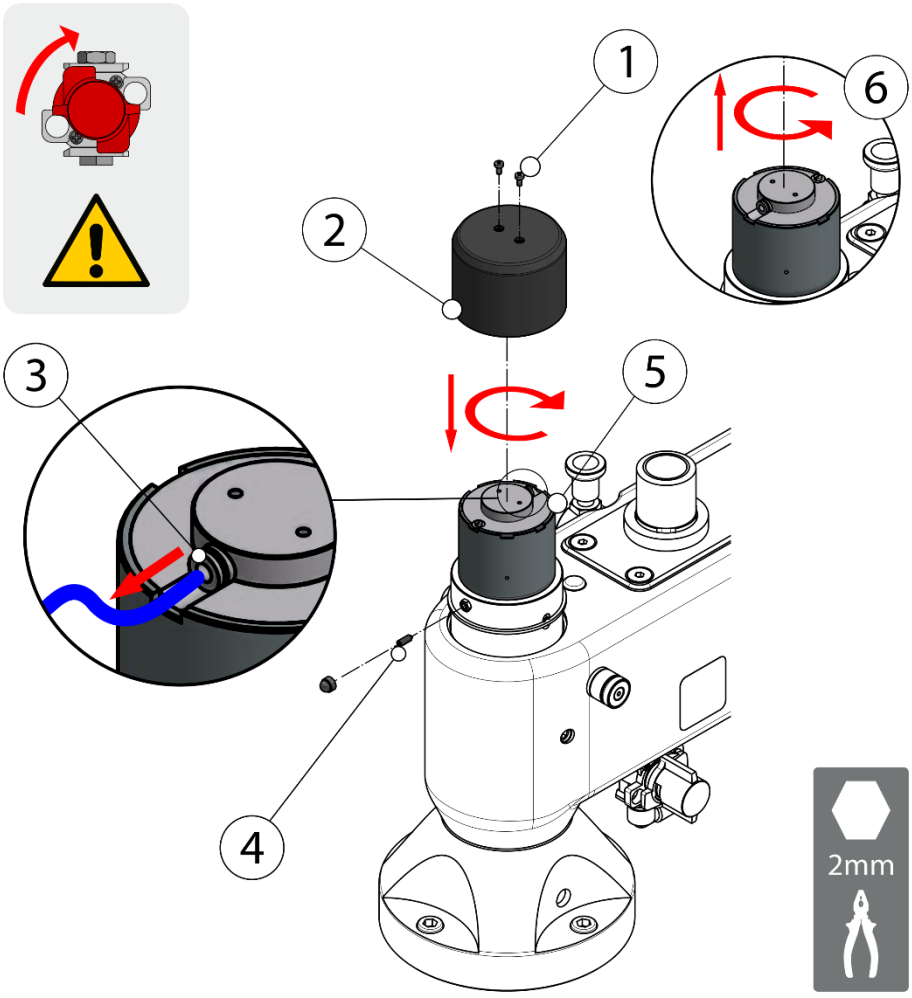
If the check is not satisfactory, the pneumatic diagram must be checked paying special attention to the clamps and the connection between tubes and taps. [See PNEUMATIC DIAGRAM page 43].



10.7.3 CHECKING THE ADJUSTMENT OF THE RADIAL CYLINDERS

Operation valid for any radial locking cylinder.

1. Release the air pressure of the arm.
2. Remove the screws (1) (2mm Allen key) and remove the cap (2).
3. Disconnect the air supply tube from the coupling (3) that supplies the cylinder.
4. Loosen the studs (4) (2 mm Allen key).
5. Screw the cylinder (5) clockwise until it stops.
6. Slightly unscrew the cylinder (5) anticlockwise (6) (approx. 1/12 turn).
7. Proceed in reverse order for assembly and verify the functioning of the lock again.



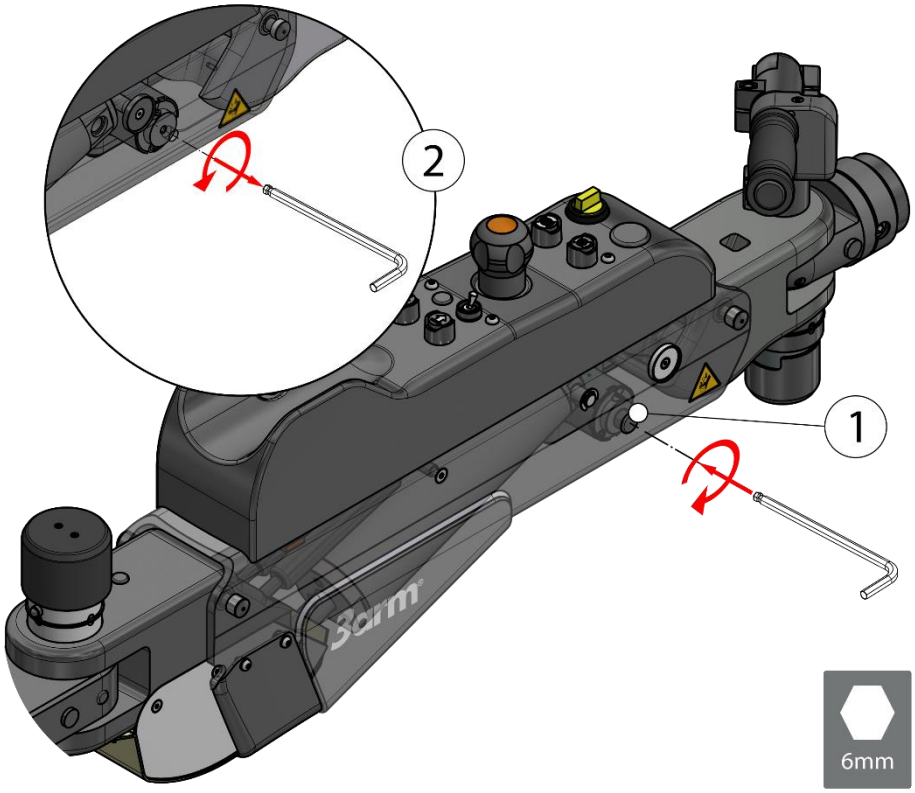
If the problem persists, it is probably due to a fault in the functioning of the cylinder (it must be replaced), or wear of the pads (they must be replaced).

10.7.4 CHECKING THE ADJUSTMENT OF THE SWIVEL CYLINDER

GENERAL CONSIDERATIONS ABOUT THE SETTINGS

DO NOT screw or unscrew the cylinder more than ½ turn to avoid pinching the pneumatic tubes.

1. Remove the cap.
2. Screw the cylinder (1) (6mm Allen key) clockwise until tight.
3. Slightly unscrew the cylinder (1) (6mm Allen key) anticlockwise (2) (approx. 1/12 turn).
4. Recheck the operation of the lock and replace the cap.

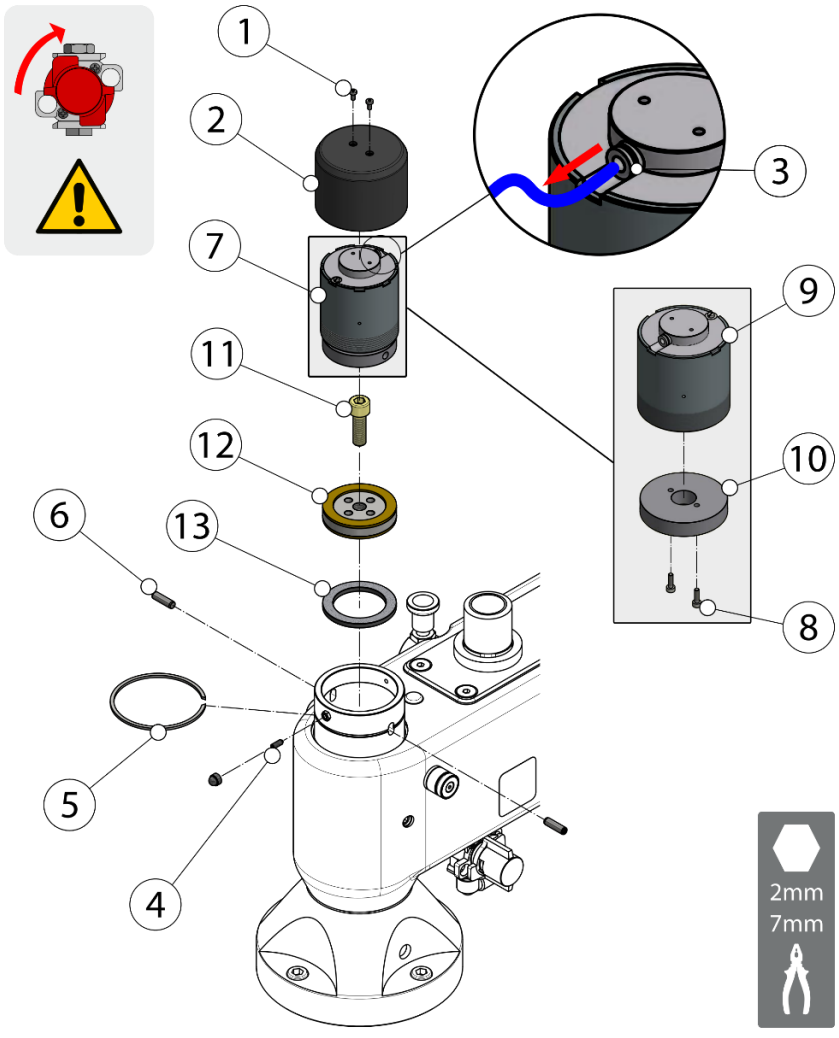


If the problem persists, it is probably due to cylinder malfunction, you should contact your 3arm® dealer for a replacement.

10.7.5 REPLACING THE CYLINDER AND/OR RADIAL PADS

Operation valid for any locking cylinder (except tilting).
If you wish to replace the locking cylinder (9) carry out steps 1- 6 and 10-16.
If you have the pad replacement kit (parts 10, 12 and 13) carry out the full process.

1. Release the air pressure of the arm.
2. Remove the screws (1) (2mm Allen key) and remove the cap (2).
3. Disconnect the air supply tube from the coupling (3) that supplies the cylinder.
4. Loosen the studs (4) (2 mm Allen key).
5. Remove the safety ring (5) and use an M4 extractor to remove the pins (6).
6. Unscrew the cylinder assembly (7) and remove it.
7. Remove the screws (8)[8] (2 mm Allen key) and separate the cylinder (9) from the pushrod (10).
8. Remove the screw (11)[9] (7 mm Allen key) and use an M10[10] extractor to take out the brake assembly with the pads (12) and remove the brake disc (13).



[8] A 2.5mm Allen key will be required for the base cylinder.
[9] An 8mm Allen key will be required for the base cylinder and a 6mm for the head cylinder.
[10] An M8 extractor will be required for the head cylinder.

9. Replace the brake assembly (12) and the brake disc (13) and screw them onto the shaft of the base with the screw (11)[11] (7 mm Allen key).
10. Replacing the pushrod (10).
11. Assemble the cylinder (9) and the pushrod (10) with the screws (8)[12] (2 mm Allen key).
12. Position the cylinder assembly (7) and screw it on clockwise until the pushrod holes coincide (10) with the elongated holes of the lug.
13. Fit the pins (6).
14. Screw the cylinder assembly (7) all the way on and unscrew it slightly, anticlockwise (approx. 1/12 turn).
15. Tighten the stud (4), fit the safety ring (5) and connect the supply pipe.
16. Put the cover in place (2) with the screws (1) (2 mm Allen key).
17. Check the lock works correctly.

INFORMATION

The cylinder replacement kit includes the part (9).
The pad replacement kit includes parts (10), (12) and (13).

[11] An 8mm Allen key will be required for the base cylinder and a 6mm for the head cylinder.
[12] A 2.5mm Allen key will be required for the base cylinder.

10.8 TIGHTENING THE SCREWS

To ensure the equipment functions correctly, it is advisable to check the tightness of all the screws periodically. The recommended period is every 6 months. The recommended torque for the 4 screws of the arm is 60Nm.

10.9 GENERAL CLEANING

It is advisable to carry out a general clean of the arm and accessories every week to keep the whole unit in good condition and prolong its useful life.

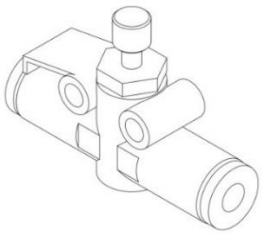
10.10 CHECKING THE PNEUMATIC CIRCUIT

Carry out a general check of the fixings and housings between tubes. Check there is no air leakage and that the connectors are working correctly.

10.11 ADJUSTING THE REGULATORS

The manipulator has two pressure regulators, located under the control cover, which guarantee a constant flow to the actuator selectors and the low pressure.

These serve to adjust the response time between actions. If the regulators were too open, there would be no time between actions and if they were too closed they would not be carried out. If this happens, adjust them.

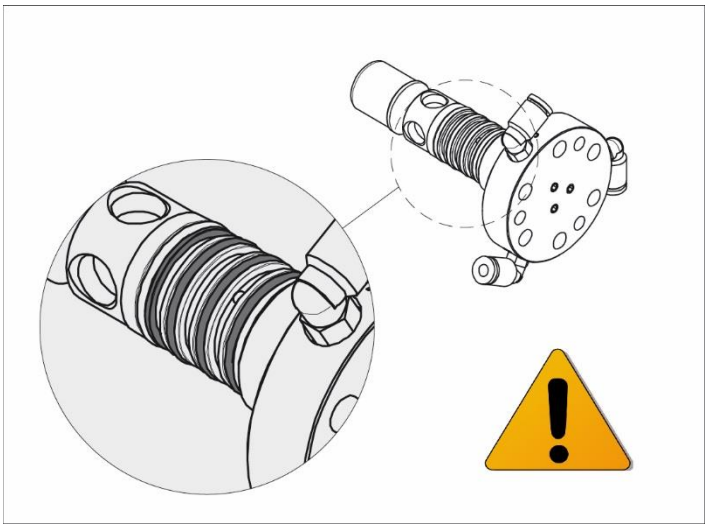


10.12 CHECKING THE JOINTS

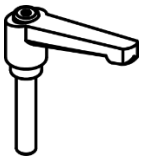
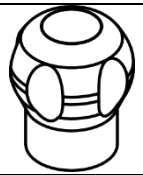
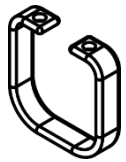
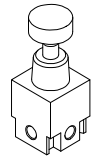
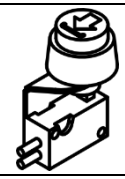
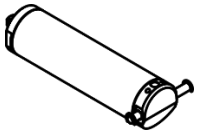
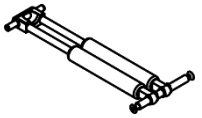
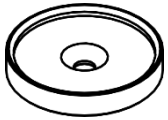
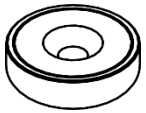
The gaskets located in the coupling allows the continuity of air flow from the manipulator to the grip system so if it is in poor condition, worn and/or badly positioned, it can cause operational problems.

Before inserting the grip system in conjunction with the manipulator head, you must:

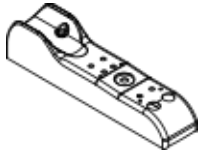
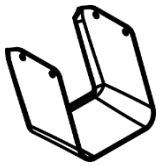
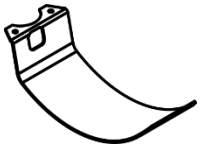
Check that each of the four joints is properly positioned in its respective housing. You must also check they are in good condition.



11 SPARE PARTS

CODE	DESCRIPTION	PICT.	CODE	DESCRIPTION	PICT.
CM145000	BASE BRAKE HANDLE		**AC004046**	POSITIONER	
CM10290C	KNOB		**W5160900**	GROMMETS UNION	
NH024016	MANOMETER		**NH030116**	REGULATOR	
M3153100R	LIFT BUTTON (UP)		**M3171800R**	LIFT BUTTON (DOWN)	
W51596A0R	CYLINDER UNIT M5		**W5xxxxA4**[13]	SHOCK ABSORBER UNIT M5	
MV401503	MAGNETIC BASE FIXING		**CL035006**	MAGNETIC BASE	

[13] XXXX corresponds to the nitrogen load in Newtons.

W52147A0	ARM COVER		**W51582A0**	LOWER ARM COVER	
W52391A0	HEAD PROTECTION COVER		**W51584A0**	CROSS PROTECTION COVER	

11.1 PNEUMATIC LOCKS (SPARE PARTS)

	CYLINDER	*UNIT BRAKES*	*COVER CYLINDER*
RADIAL BASE	W5178900	W5179500	W5180600
RADIAL CROSS	W5179000	W5179800	W5180600
RADIAL HEAD	MV405504	MV4064A4	MV405903
SWIVEL	W5179400	MV406604	-

12 WARRANTY

See attached guarantee document.

13 GUIDELINES FOR PACKAGING, TRANSPORT AND DISMANTLING

13.1 PACKAGING

Follow the instructions below for packing the equipment for location changes or shipments for repair and maintenance.

13.1.1 Preparatory measures

The equipment must be placed out of service. Assembling the "transport safety elements" will prevent movement during transport and thus possible damage to the installation.

13.1.2 Choice of packaging

For long transport distances, the components of the production installation must be packed in such a way that they are protected from atmospheric conditions.

13.1.3 Inscription on the packaging

Observe the specific provisions of the country in which the equipment is transported. In fully closed packaging, an indication must be placed on the packaging indicating where the top is.

13.1.4 Packaging procedure

Place the components of the machine on manufactured wooden pallets. Use lashing straps to ensure the components are secured against possible falls. Attach all the technical documentation that must accompany the machine.

13.2 TRANSPORT

The following data must be taken into account for transport.

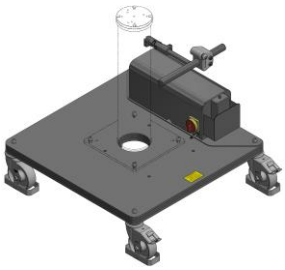
- ✓ External dimensions depending on the segment (width x height x depth), approx. mm: 1100 x 500 x 415 mm
- ✓ Total weight depending on the segment: approx. 50-55 kg

13.3 DISASSEMBLY

- ✓ The equipment must be taken out of service by duly trained and authorised personnel.
- ✓ The machine must be dismantled taking the safety instructions, waste disposal and recycling into account.
- ✓ Protect the environment. The machine must be disposed of pursuant to current regulations and guidelines on safety, noise prevention, environmental protection and accident prevention.

14 ACCESSORIES

TROLLEY



To move the work unit.
It has four orientable wheels.

DESCRIPTION	DIMENSIONS	
Trolley 700	700x700 mm	27 9/16" x 27 9/16"
Trolley 900	900 x 900 mm	35 7/16" x 35 7/16"
Electric trolley	800x800 mm	31 1/2" x 31 1/2"
Electric trolley	900 x 900 mm	35 7/16" x 35 7/16"

FIXED COLUMN PR

To secure to the floor using four metal studs.

DESCRIPTION/DIMENSIONS	
Column 275 PR	10 13/16″
Column 375 PR	14 3/4″
Column 450 PR	17 3/4"
Column 635 PR	25″
Column 740 PR	29 1/8"
Column 850 PR	33 7/16"
Column 1100 PR	43 5/16″
Column 1350 PR	53 1/8″
Column 1600 PR	63″

LIFT PR

It consists of a telescopic column and a pneumatic cylinder with anti-rotation.

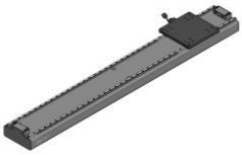
DESCRIPTION	VERTICAL TRAVEL
Lift 300 PR	300 mm – 11 7/8"
Lift 550 PR	550 mm – 21 5/8"
Lift 750 PR	750 mm – 29 1/2"

EXTENSION

Extender that enables the arm's working area to be increased. It can also be installed on other accessories, such as column, lift, beam, etc.

DESCRIPTION	ADDITIONAL WORK AREA
Extension 600	600 mm – 23 5/8"
Extension 1000	1000 mm – 39 3/8"

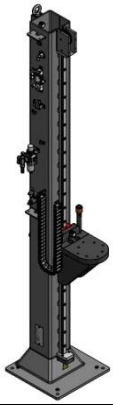
FLOOR RAIL



Rail to fasten to the floor and on which the different columns and lifts can be fastened. Several sections can be joined from a base section 2 m. The horizontal position can be locked at any point.

CODE	DESCRIPTION	TRAVEL
CL040000	Floor rail	1520 mm – 59 13/16"

COLUMN D100



Pneumatic lift. The vertical position can be locked at any point, it has a pneumatic cylinder. It can be secured to the ground, on a trolley or on the ground rail to have movement on two shafts.

DESCRIPTION	VERTICAL TRAVEL
Column 1500 D100	952 mm – 37 7/16″
Column 2000 D100	1455 mm – 57 5/16"
Column 2500 D100	1999mm – 78 11/16"

BASE ROTATION LIMITER

Support that limits the rotation of the radial arm of the equipment. The stops can be moved to adjust the range of rotation.

CODE	DESCRIPTION
LG000104	Rotation Limiter

14.1 COMPATIBILITY TABLE

Accessory	M5
TROLLEY	●
COLUMN PR	●
LIFTER PR	●
EXTENSION	●
FLOOR RAIL	●
COLUMN D100	●
ROTATION LIMITER	●

● = Compatible
⦸ = NOT Compatible

NOTES

DATE	DESCRIPTION

CE STATEMENT OF COMPLIANCE

The manufacturer:

Company: TECNOSPIRO MACHINE TOOL, S.L.U.
Address: P.I. Pla dels Vinyats I, s/n nau 1
City: Sant Joan de Vilatorrada
Country: Spain - EU

Declares that this product:

Name:	M5 Manipulator
Serial number:	From 002 - 039

It is classified as a machine according to the Machinery Directive 2006/42/EC and to which this Declaration refers, and complies with the following European EC Directives, and their applicable Essential Health and Safety Requirements (EHSR):

2006/42/EC – Machinery Directive

2014/68/EU – Pressure Equipment Directive

Authorised for documentation:

Mr Ramon Jou Parrot of TECNOSPIRO MACHINE TOOL, S.L.U.

Sant Joan de Vilatorrada, Monday, 27 May 2024

Ramon Jou Parrot, Technical Director

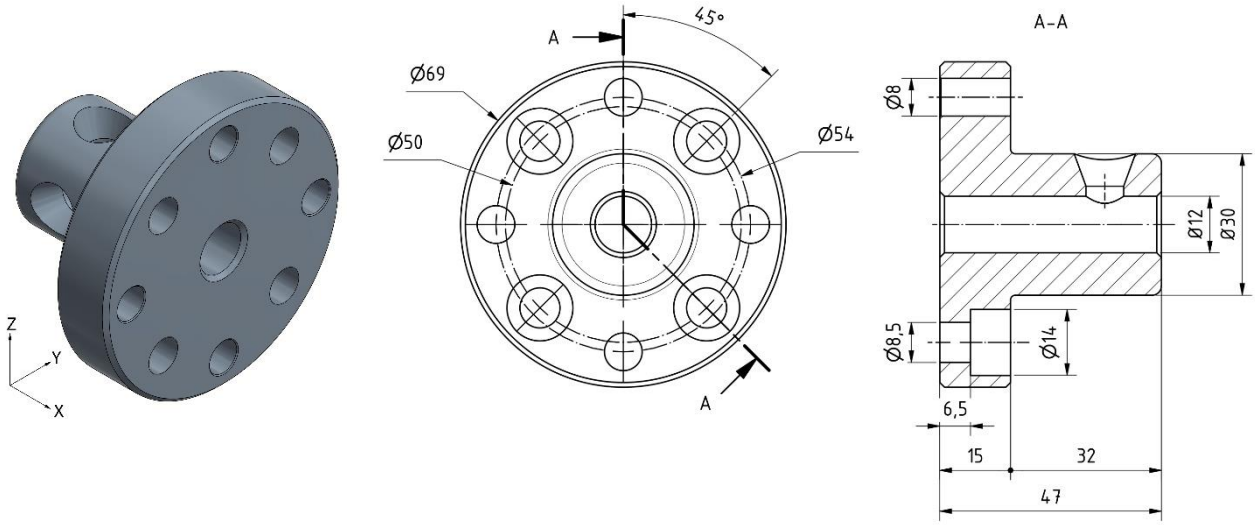
HEAD ATTACHMENT

TABLE OF CONTENTS

1 HEADS

To complement the manoeuvrability of your equipment, the M5 Manipulator has various heads that make it possible to move and rotate the load according to your needs:

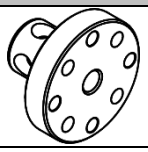
1.1 HORIZONTAL HEAD (CA5)



X: 4x90º
Z: ±90º (Swivel base)

This head allows manual rotation of the crankpin every 90º. To do this:

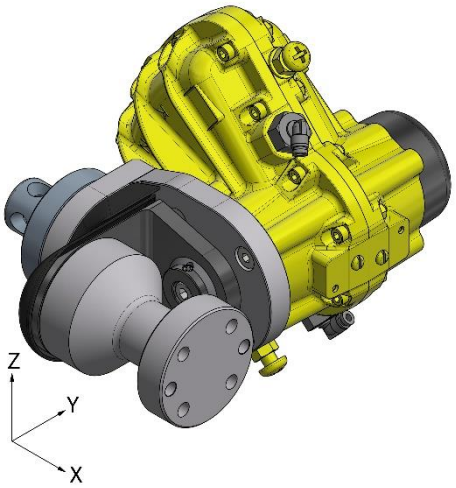
1. Loosen the studs (8 mm Allen key) in the Manipulator until the crankpin can rotate freely.
2. Rotate the crankpin (90º, 180º or 270º).
3. Retighten the studs securing the crankpin.

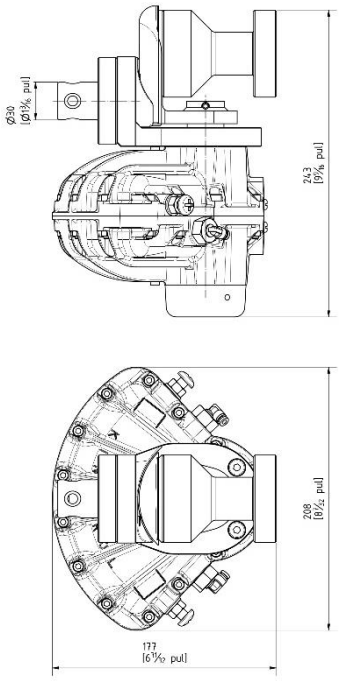
CODE	*DESCRIPTION*	*PICT.*
W5157600	HORIZONTAL HEAD M5 CA5	

1.2 REVOLVING HEAD (CC5)

The CC5 is a rotation head for the M5 Manipulator, which pivots with respect to the horizontal axis and allows us to limit and customise the rotation angle as defined by the customer.

1.2.1 REVOLVING HEAD WITHOUT STOP

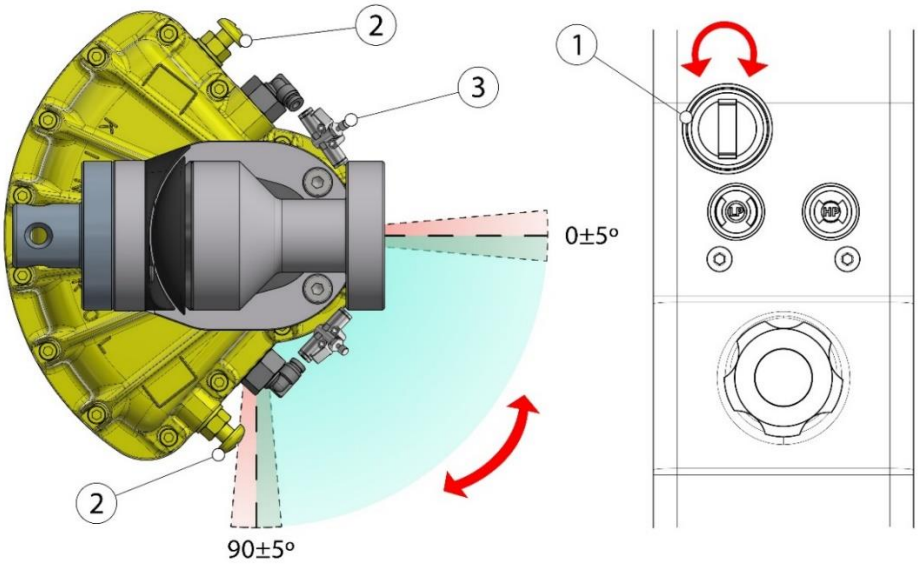




Y: 90º±10º
Z: ±90º (Swivel base)

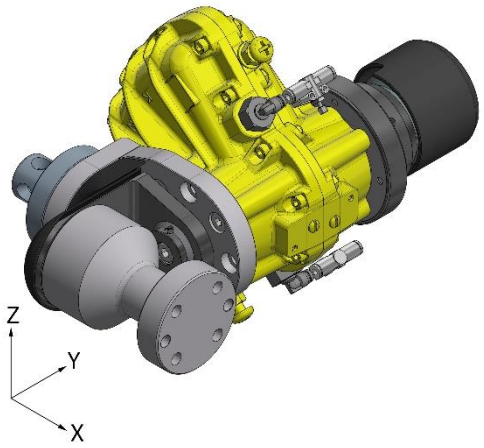
This head makes it possible to swivel the load[14]. To do this:

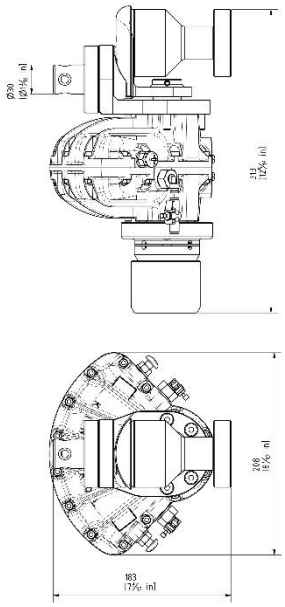
1. Rotate the selector (1).
2. Tighten or loosen the bolts (2) to modify the working angle by ±5º at each limiter.
3. Adjust the rotation speed with the flow regulators (3).



[14] Models: - 90º
- Customised angular stroke (less than 90º)

1.2.2 REVOLVING HEAD WITH LOCK (CC5X)

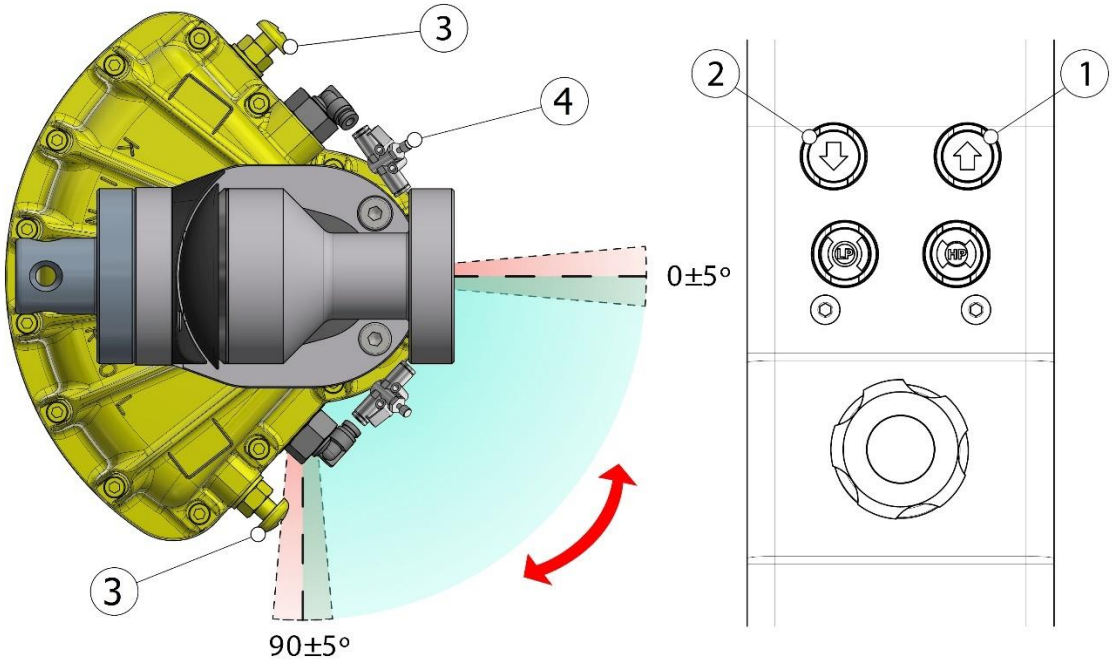




Y: 90º±10º (Lockable)
Z: ±90º (Swivel base)

This head allows the load to be tilted[15] and incorporates a pneumatic lock to brake the head in the desired position. To do this:

1. Press the button (1) to tilt the load upwards.
2. Press button (2) to tilt the load downwards.
3. Tighten or loosen the bolts (3) to modify the working angle by ±5º at each limiter.
4. Adjust the rotation speed with the flow regulators (4).

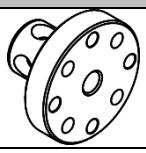
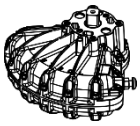
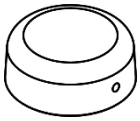
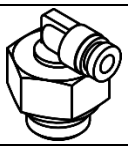
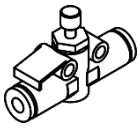
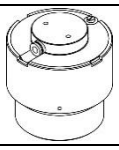


[15] Models: - 90º
- Customised angular stroke (less than 90º)

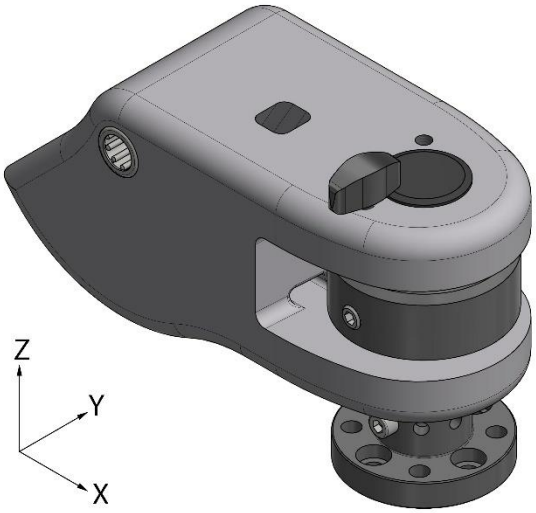
It is easy and intuitive to operate and uses two push buttons (1 and 2) on the control panel to operate the rotary movement to one side or the other. When either of the two push buttons are released, the head stops rotating and is instantly locked, so a central stop position can be found in a very intuitive way.

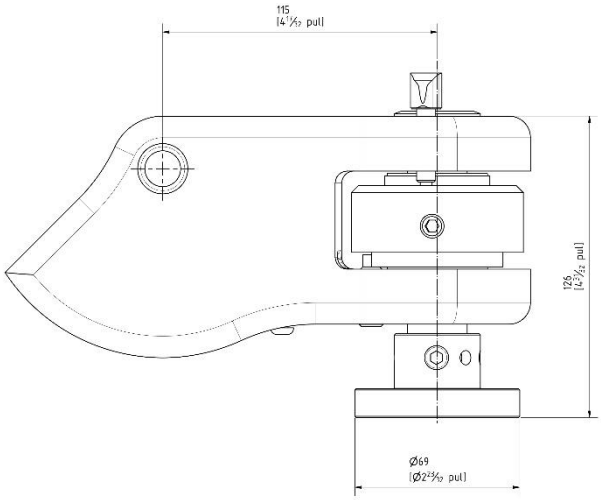
CAUTION

If you change the load on the head (or after a prolonged period of inactivity) there could be a sudden reaction of the head when starting the movement, because the air chambers of the actuator need to be filled in order to start working optimally.

CODE	*DESCRIPTION*	*PICT.*
W5157600	HORIZONTAL HEAD M5 CA5	
W5165500	REVOLVING MODULE - K08	
W3104000	REVOLVING BACK COVER	
NH027956	CONNECTOR KQB2L04-G02	
NH027466	FLOW REGULATOR AS1002F-04	
W5179000	LOCKING CYLINDER D48	

1.3 VERTICAL HEAD (CD5)

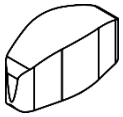




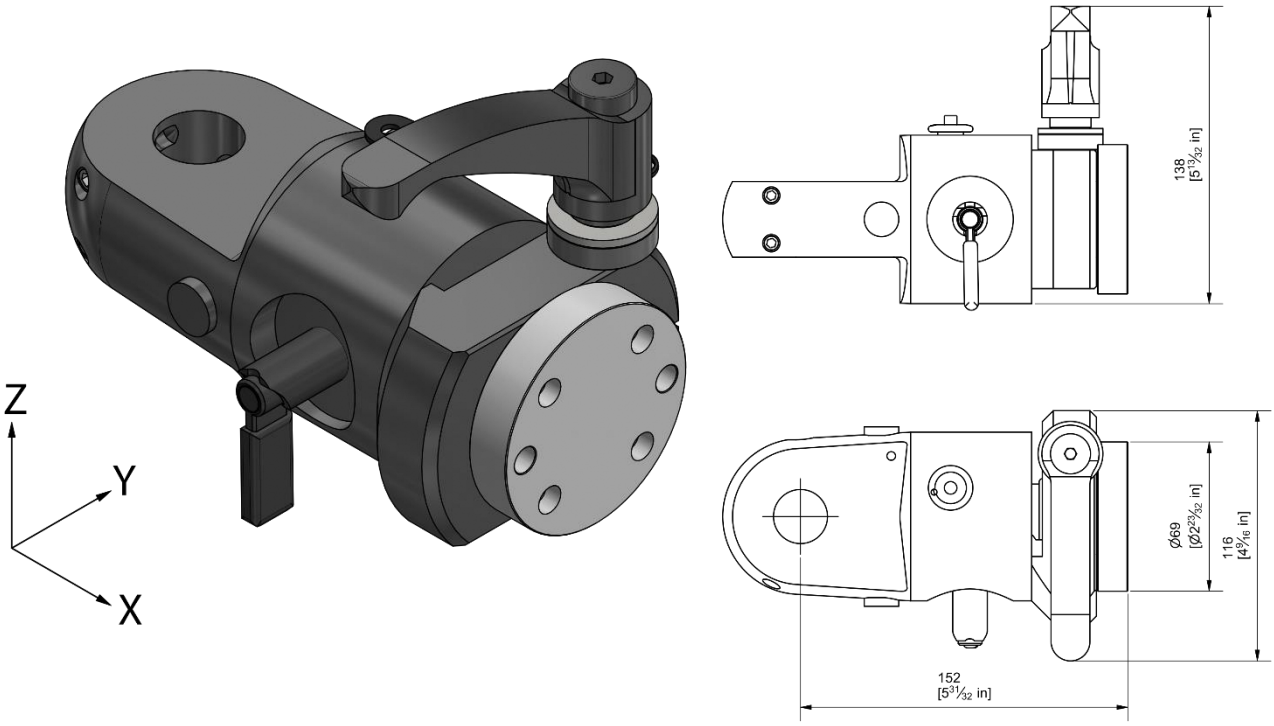
Z: 340°

This head makes it possible to rotate the load manually. To do this:

1. Adjust the rotation speed with the friction handle (1).

CODE	DESCRIPTION	PICT.
W5174500	STRIP BW100 M5	
CA018746	NYLON NUT THREAD BOLT M8x40	
AC004036	HANDLE -M8	

1.4 MANUAL ROTATING HEAD WITH LOCK (CE5)

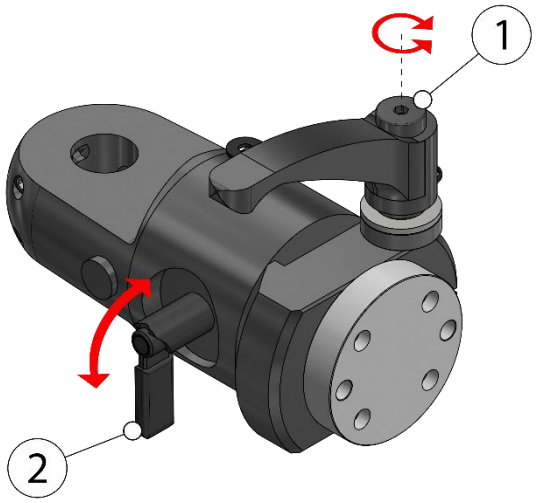


X: ±180º[16] (4x90º)
Z: ±90º (Swivel base)

This head allows manual rotation of the crankpin. To do this:

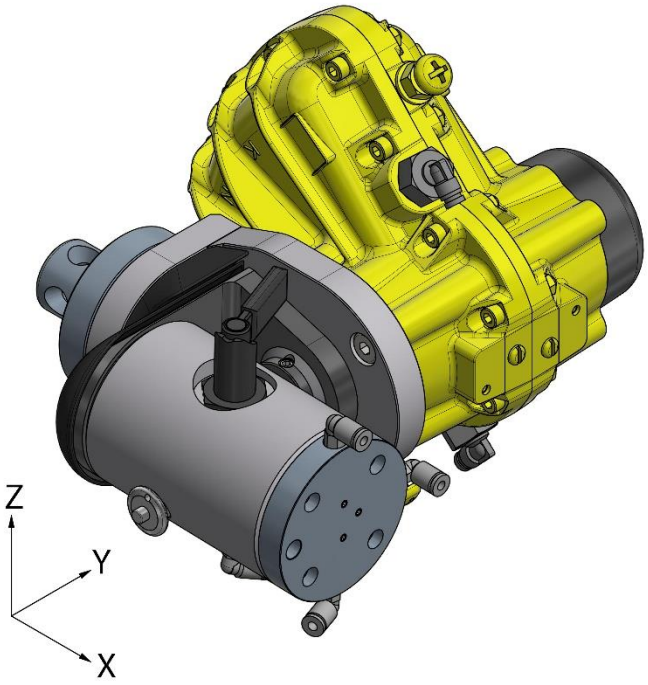
1. Loosen the handle (1) and turn the positioner (2) 180°, the crankpin will be free.
2. Move the crankpin to the desired position (90º, 180º -90º or -180º).
3. Turn the positioner (2) back to its initial position and tighten the handle (1).

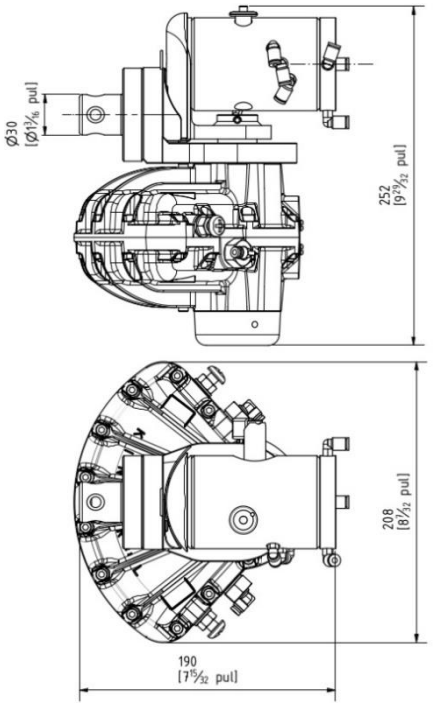
If another working angle is desired, leave the positioner (2) free and firmly tighten the handle (2) to lock.



[16] In order to avoid pinching any pneumatic tube. If you do not have a tooling assembly with pneumatic action, you can rotate 360º

1.5 REVOLVING + MANUAL ROTATING HEAD (CF5)





X: 4x90º
Y: 90º±10º [17]
Z: ±90º (Swivel base)

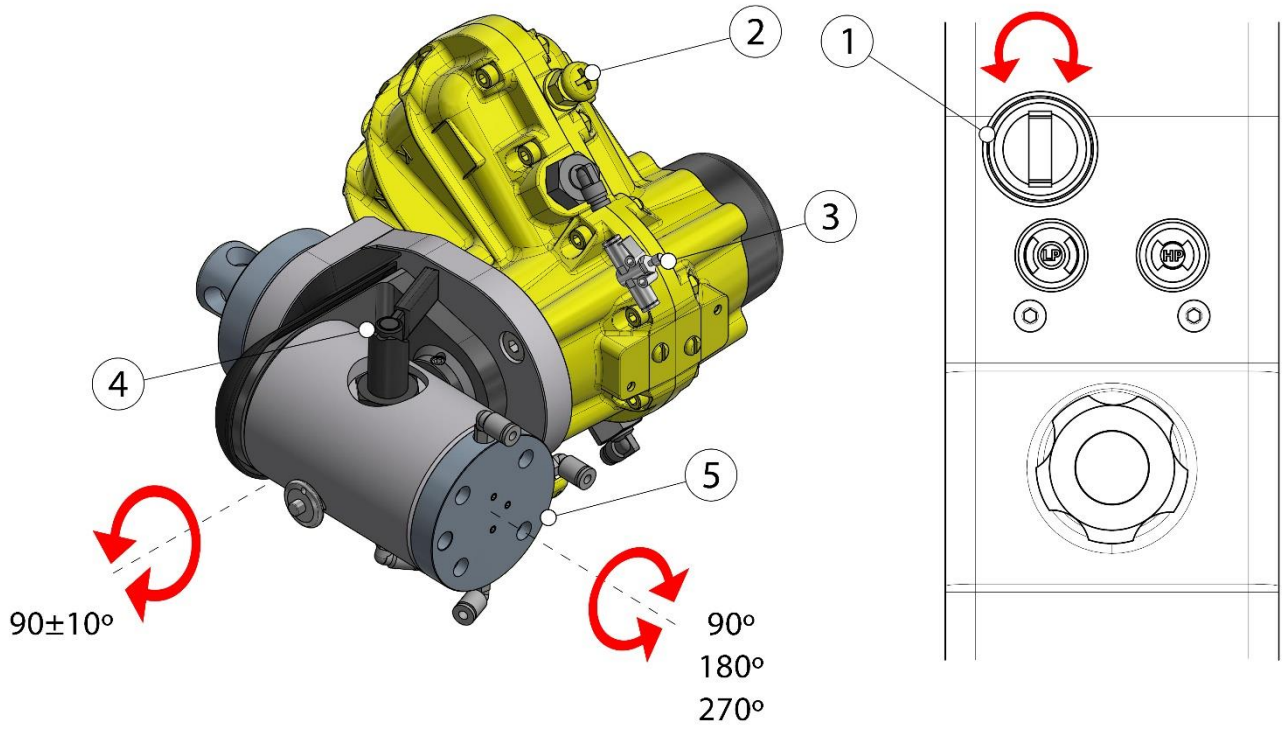
This head makes it possible to swivel and rotate the load. To swivel:

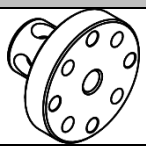
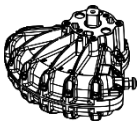
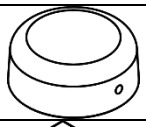
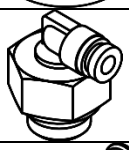
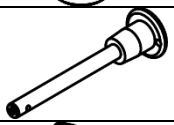
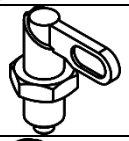
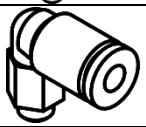
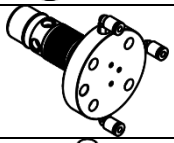
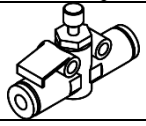
1. Rotate the selector (1).
2. Tighten or loosen the bolts (2) to modify the working angle by ±5º at each limiter.
3. Adjust the rotation speed with the flow regulators (3).

To rotate:

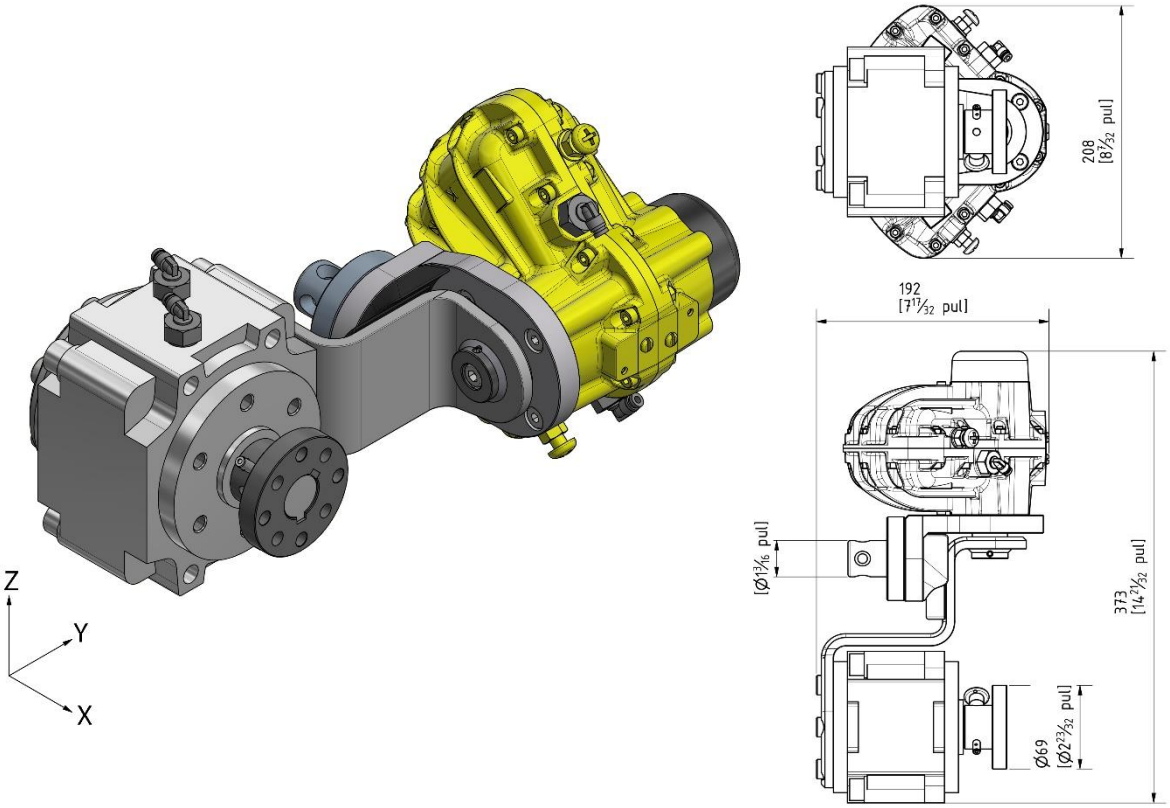
1. Rotate the positioner (4) 180º to release the crankpin (5).
2. Move the crankpin (5) to the desired position (90º, 180º or 270º).
3. Rotate the positioner (4) back to its initial position.

[17] Models: - 90º
- Customised angular stroke (less than 90º)



CODE	DESCRIPTION	PICT.
W5157600	HORIZONTAL HEAD M5 CA5	
W5165500	REVOLVING MODULE - K08	
W3104000	REVOLVING BACK COVER	
NH027956	CONNECTOR KQB2L04-G02	
CM123300	KIPP POSITIONER Ø6x50	
W5206400	NORELEM POSITIONER M16x1.5	
NH027016	CONNECTOR KQB2L04-M5	
W5174800	CRANKPIN CR M5	
NH027466	FLOW REGULATOR AS1002F-04	

1.6 REVOLVING + ROTATING HEAD (CG5)



X: 90º / 180º / 270º
Y: 90º±10º [18]
Z: ±90º (Swivel base)

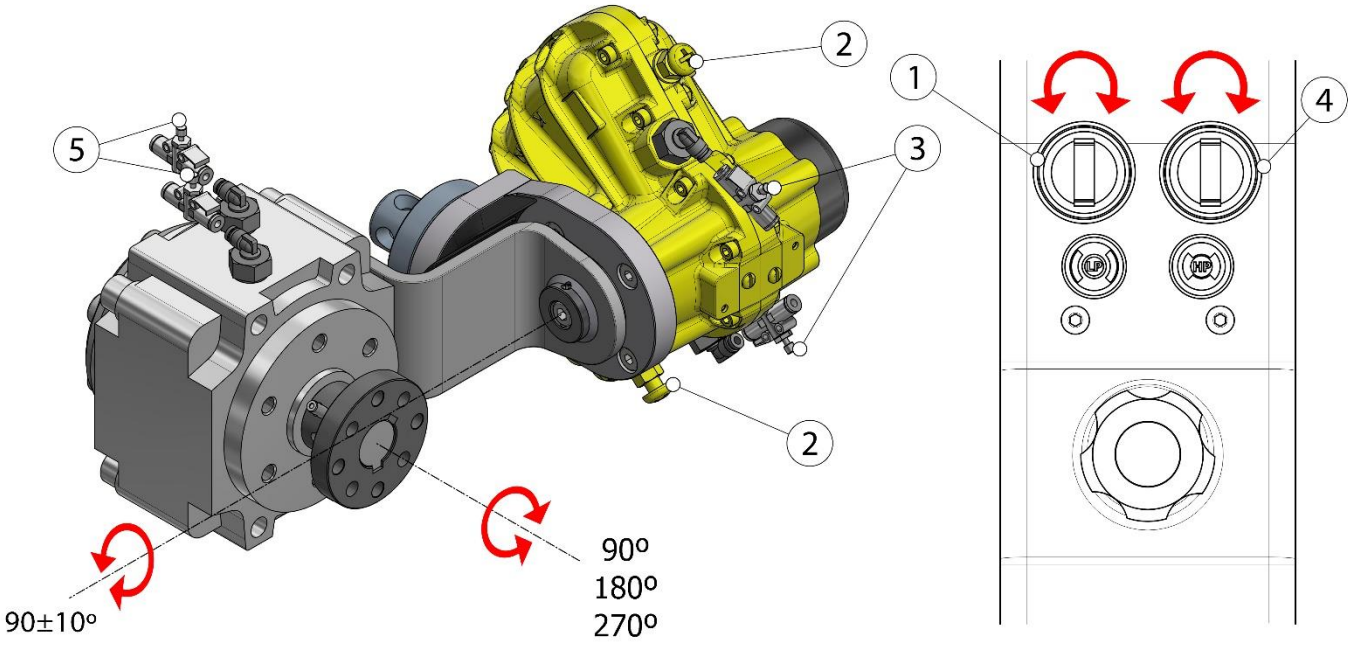
This head makes it possible to swivel and rotate the load. To swivel:

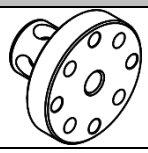
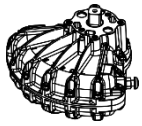
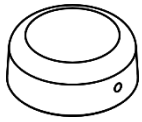
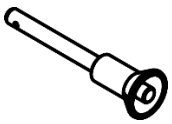
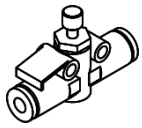
1. Rotate the selector (1).
2. Tighten or loosen the bolts (2) to modify the working angle by ±5º at each limiter.
3. Adjust the rotation speed with the flow regulators (3).

To rotate:

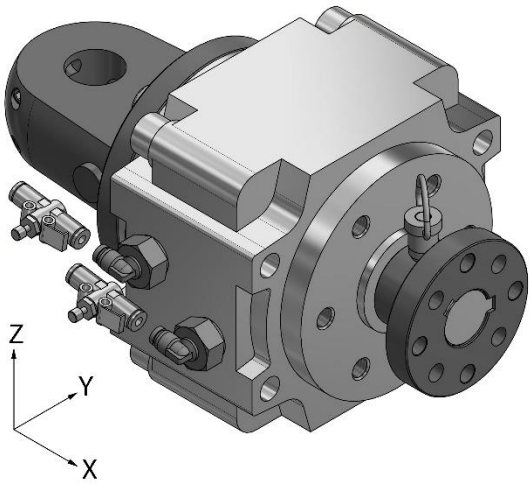
1. Rotate the selector (4).
2. Adjust the rotation speed with the flow regulators (5).

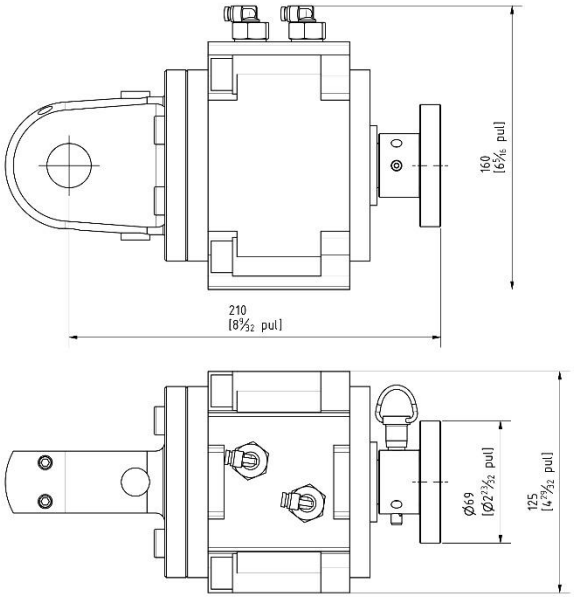
[18] Models: - 90º
- Customised angular stroke (less than 90º)



CODE	DESCRIPTION	PICT.
W5157600	HORIZONTAL HEAD M5 CA5	
W5165500	REVOLVING MODULE - K08	
W3104000	REVOLVING BACK COVER	
CM125000	KIPP POSITIONER Ø6x40	
NH027466	FLOW REGULATOR AS1002F-04	
NH027956	CONNECTOR KQB2L04-G02	
W5174500	STRIP BW100 M5	
CM121800	CABLE RETENTION	

1.7 ROTATING HEAD (CH5)

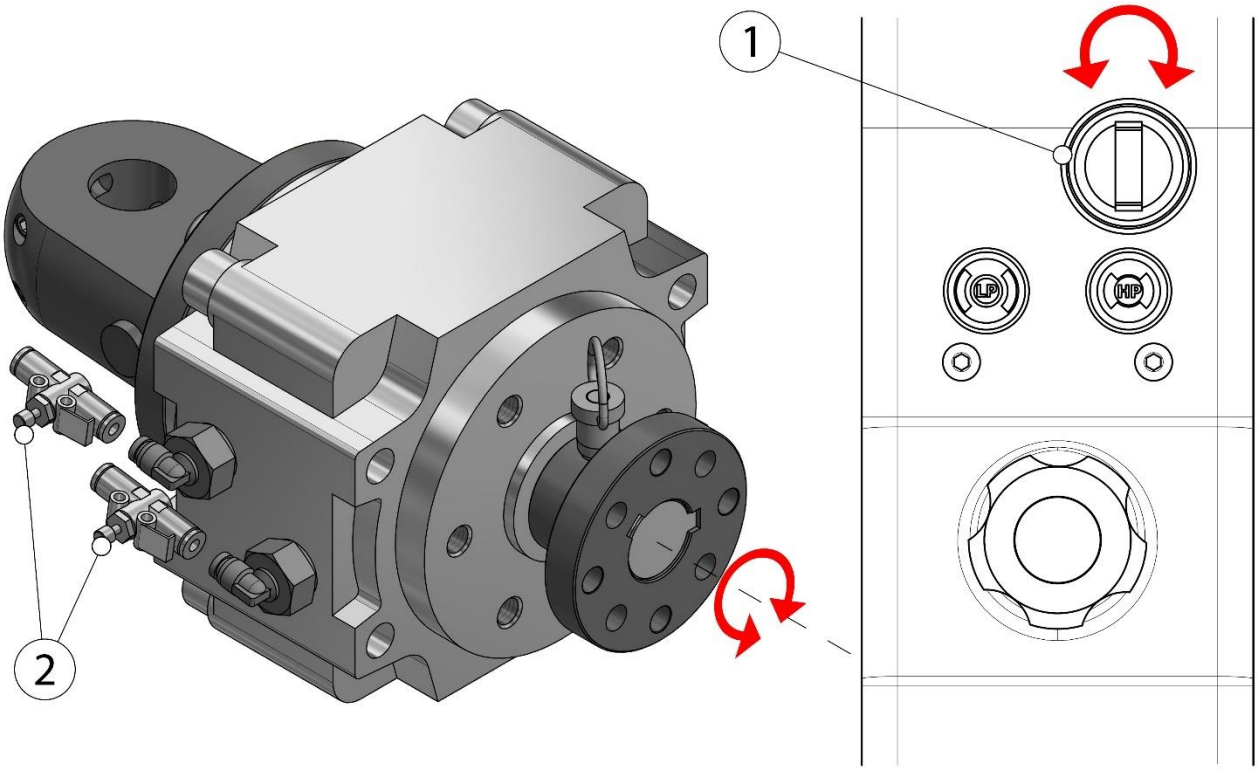


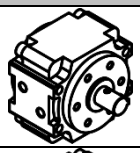
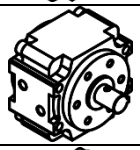
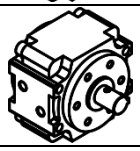
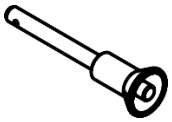
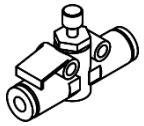
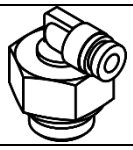


X: 90º / 180º / 270º
Z: ±90º (Swivel base)

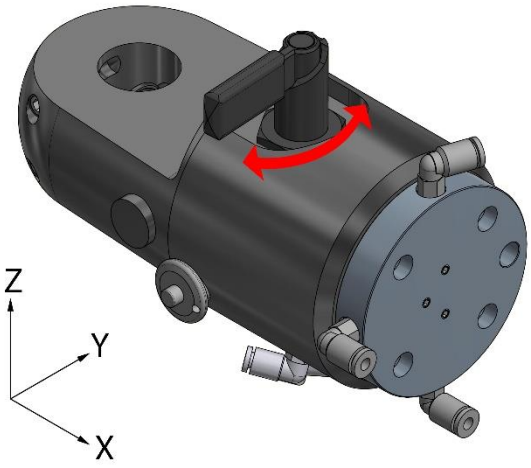
This head makes it possible to rotate the load. To do this:

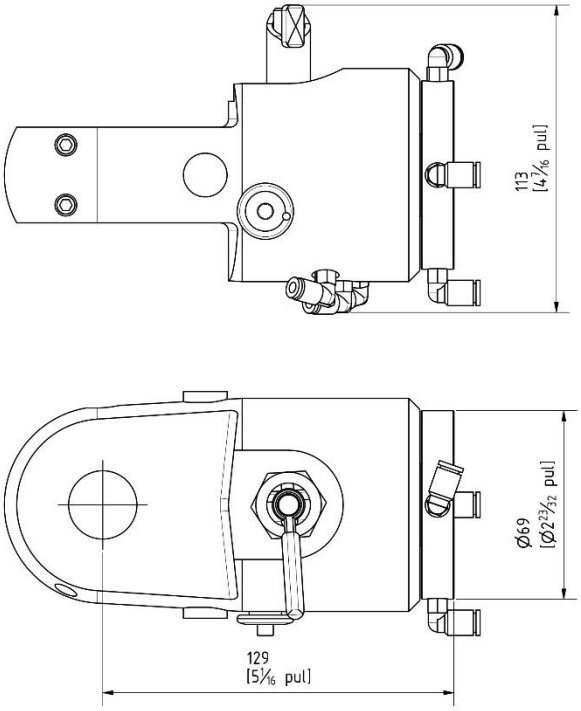
1. Rotate the selector (1).
2. Adjust the rotation speed with the flow regulators (2).



CODE	DESCRIPTION	PICT.
W5177200	ROTATION ACTUATOR CRB1BW100-90D-XF	
W5181100	ROTATION ACTUATOR CRB1BW100-180S-XF	
W5190700	ROTATION ACTUATOR CRB1BW100-270S-XF	
CM125000	KIPP POSITIONER Ø6x40	
NH027466	FLOW REGULATOR AS1002F-04	
NH027956	CONNECTOR KQB2L04-G02	
W5174500	STRIP BW100 M5	
CM121800	CABLE RETENTION	

1.8 MANUAL ROTATING HEAD (CI5)

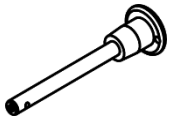
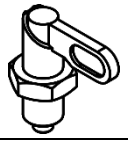
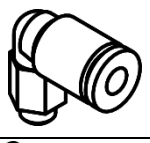
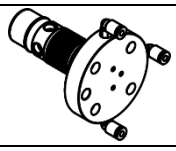




X: 360º (4x90º)
Z: ±90º (Swivel base)

This head allows manual rotation of the crankpin every 90º. To do this:

3. Rotate the positioner 180º to release the crankpin.
4. Move the crankpin to the desired position (90º, 180º or 270º).
5. Rotate the positioner back to its initial position.

CODE	*DESCRIPTION*	*PICT.*
CM123300	KIPP POSITIONER Ø6x50	
W5206400	NORELEM POSITIONER M16x1.5	
NH027016	CONNECTOR KQB2L04-M5	
W5174800	CRANKPIN CR M5	

ACTUATOR ATTACHMENT

TABLE OF CONTENTS

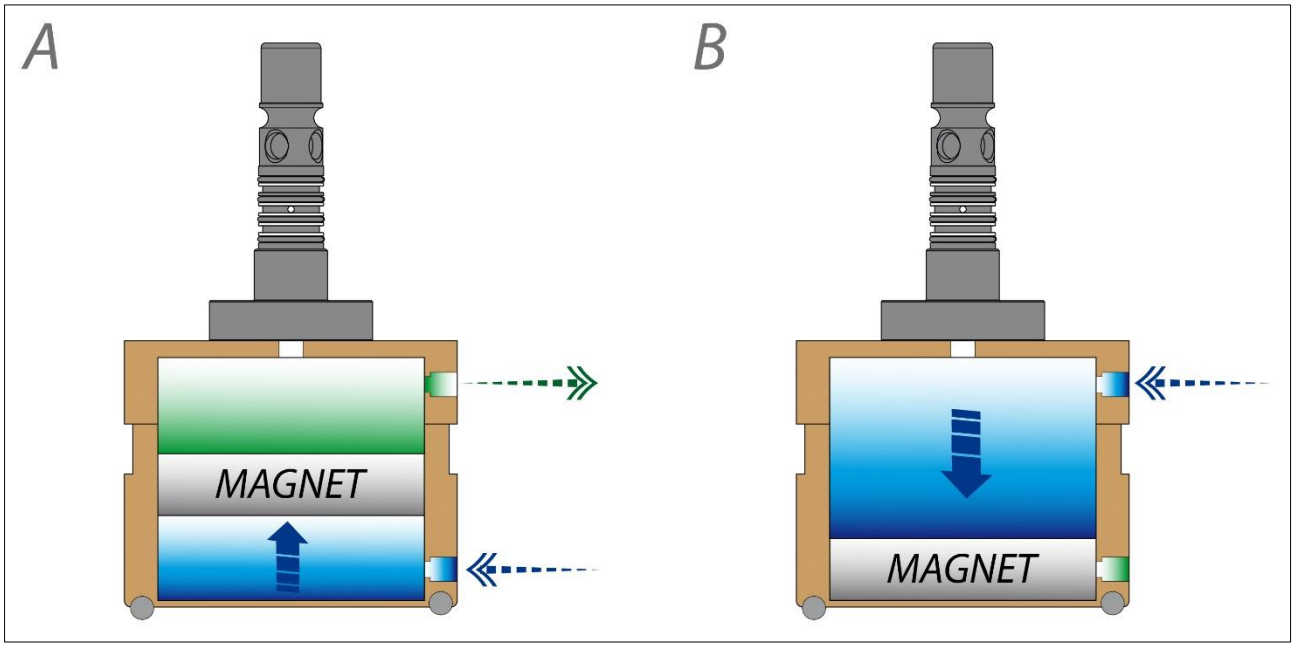
1 ACTUATORS

To complement the functionality of your equipment, the M5 Manipulator has various actuators that make it possible to grip and secure the load according to your needs:

1.1 MAGNET

1.1.1 DESCRIPTION AND OPERATING PRINCIPLE

The magnet-type load clamping device provides the M5 manipulator with the appropriate complement for handling loads of ferrous materials with flat surfaces exceeding 2 mm in thickness (e.g. bars, plates, etc.). In the loose workpiece position, the air pushes the magnet away from the gripping surface. (Drawing to the left - A). In the position to grip the part the air pushes the magnet down, closer to the grip surface (Drawing on the right - B).



WARNING

- ✓ The selection and design must be made carefully for each working load.
- ✓ The integrator/end user must ensure that the load securing device is suitable for the end application.

ADDITIONAL INFORMATION

- ✓ The models with rubber will not mark the surface of the workpiece and increases the friction with the workpiece.

1.1.2 OPERATIVE

WARNING

- ✓ The sequence described below supposes that the installation, settings such as the Opening of the main valve, the regulation of the supply pressure, the balancing of the arm at no load and with load, and the correct integration have been carried out following the guidelines indicated in the manual.
- ✓ Do not release the working load (low pressure) until it is resting on an appropriate, safe surface.
- ✓ Verify that the manipulator and the holding device receive compressed air before each use.

1. Bring the manipulator close to the workload and ensure the holding device remains in contact with the grip surface of the load.
2. Activate the high pressure [See OPERATION page 30].

NOTE: If the high pressure is not activated (and subsequently cannot hold the load) it is likely that the clamping device is not in contact with the workload or only partially. In this case the safety micro-valve will not give the necessary signal to activate the high pressure. [See SAFETY MICRO page 42].

3. Move the working load to the destination location. Rest the load on an appropriate, safe surface.
4. To release the load, activate the low pressure [See OPERATION page 30]. The magnet will stop working.

FAILURE IN THE AIR SUPPLY

- ✓ Although the manipulator's design aims to minimise possible damage arising from an inopportune start-up after a failure in the air supply, the operator must bear in mind that the swivel arm of the M5 Manipulator, as well as its load securing device and consequently the working load can descend sharply and unexpectedly, or ascend suddenly and inappropriately after the air supply is re-established.
- ✓ If the air supply is cut off, close the main valve and move the manipulator to its retracted or parking position, ensuring that the closing device is activated [See OPENING AND CLOSING THE MAIN VALVE and Retracted position – Parking page 22 and 14].

1.2 CLAMP

1.2.1 DESCRIPTION AND OPERATING PRINCIPLE

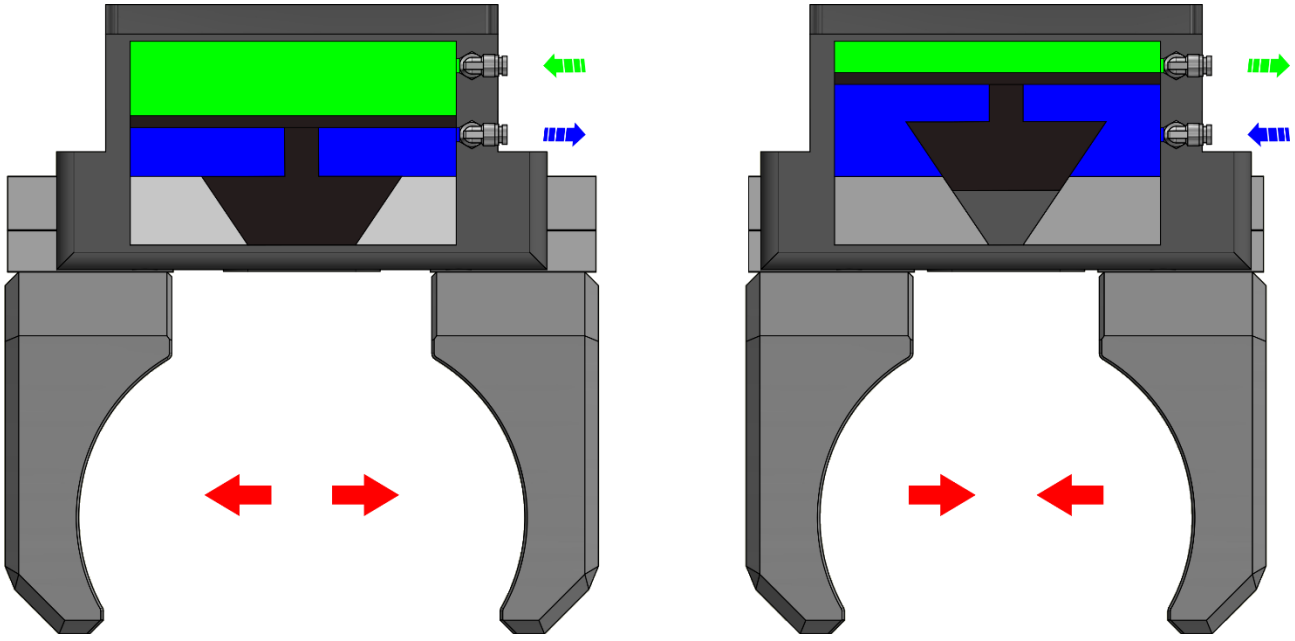
The gripper type holding device provides the M5 Manipulator with a good grip of the working load, as well as of the movements necessary for suitable manipulation.

Its main application is the manipulation and lifting of preferably cylindrical or circular loads. (Example: crankshafts and camshafts).

The jaws are opened and closed using the compressed air, which pushes the piston up or down. The lever system of the kinematic system converts the vertical movement of the piston into a synchronous angular movement of the jaws (in angular models) or a parallel movement (in parallel models).

WARNING

- ✓ The selection and design must be made carefully for each working load.
- ✓ The integrator/end user must ensure that the load securing device is suitable for the end application.



1.2.2 OPERATIVE

WARNING

- ✓ The sequence described below supposes that the installation, settings such as the Opening of the main valve, the regulation of the supply pressure, the balancing of the arm at no load and with load, and the correct integration have been carried out following the guidelines indicated in the manual.
- ✓ Do not release the working load (low pressure) until it is resting on an appropriate, safe surface.
- ✓ Verify that the manipulator and the holding device receive compressed air before each use.

1. Bring the manipulator close to the workload and ensure the holding device remains in contact with the grip surface of the load.
2. Activate the high pressure [See OPERATION page 30].

NOTE: If the high pressure is not activated (and subsequently cannot hold the load) it is likely that the clamping device is not in contact with the workload or only partially. In this case the safety micro-valve will not give the necessary signal to activate the high pressure. [See SAFETY MICRO page 42].

3. Move the working load to the destination location. Rest the load on an appropriate, safe surface.
4. To release the load, activate the low pressure [See OPERATION page 30]. The magnet will stop working.

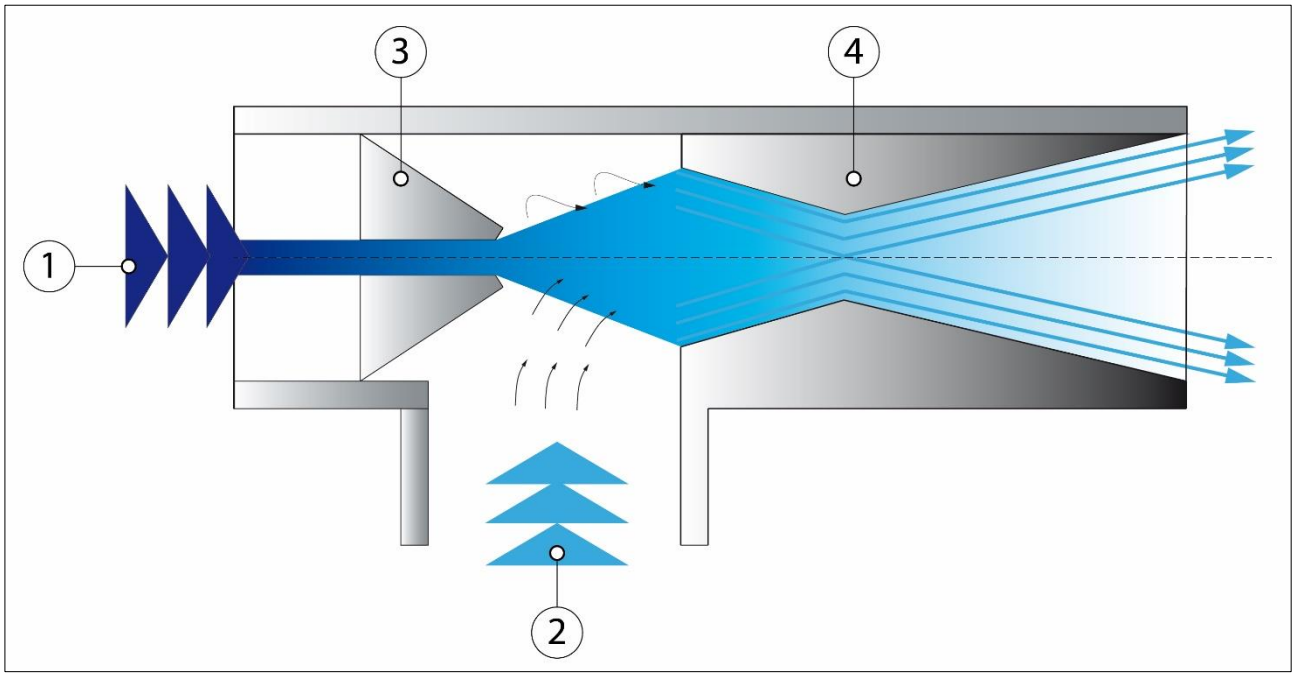
FAILURE IN THE AIR SUPPLY

- ✓ The grippers have springs that keep them closed if the air supply is cut off (there is also the inverse system which opens the grippers).
- ✓ Although the manipulator's design aims to minimise possible damage arising from an inopportune start-up after a failure in the air supply, the operator must bear in mind that the swivel arm of the M5 Manipulator, as well as its load securing device and consequently the working load can descend sharply and unexpectedly, or ascend suddenly and inappropriately after the air supply is re-established.
- ✓ If the air supply is cut off, close the main valve and move the manipulator to its retracted or parking position, ensuring that the closing device is activated [See OPENING AND CLOSING THE MAIN VALVE and Retracted position – Parking page 22 and 14].

1.3 SUCTION CUP

1.3.1 DESCRIPTION AND OPERATING PRINCIPLE

The suction cup type load securing device together with the M5 Manipulator makes it possible to grip and manipulate the working load creating a vacuum. The vacuum is generated with the Venturi effect, in which a nozzle (3) is fed with compressed air (1). The jet created drags the ambient air (2) into its turbulence, which then passes into the mixer (4) to be expelled. This action creates the depression that generates the necessary vacuum.



WARNING

- ✓ The selection and design must be made carefully for each working load.
- ✓ The integrator/end user must ensure that the load securing device is suitable for the end application.

1.3.2 OPERATIVE

WARNING

- ✓ The sequence described below supposes that the installation, settings such as the Opening of the main valve, the regulation of the supply pressure, the balancing of the arm at no load and with load, and the correct integration have been carried out following the guidelines indicated in the manual.
- ✓ Do not release the working load (low pressure) until it is resting on an appropriate, safe surface.
- ✓ Verify that the M5 Manipulator and the holding device receive compressed air before each use.
- ✓ Keep the grip surface as smooth and clean as possible.

1. Bring the manipulator close to the workload and ensure the holding device remains in contact with the grip surface of the load.
2. Activate the high pressure [See OPERATION page 30].

NOTE: If the joystick cannot be unlocked, it is likely that the vacuum switch is detecting insufficient vacuum pressure, so it will not give the signal necessary to activate the high pressure [See VACUUM SWITCH page 42].

3. Move the working load to the destination location. Rest the load on an appropriate, safe surface.
4. To release the load, activate the low pressure [See OPERATION page 30]. The magnet will stop working.

FAILURE IN THE AIR SUPPLY

- ✓ Although the manipulator's design aims to minimise possible damage arising from an inopportune start-up after a failure in the air supply, the operator must bear in mind that the swivel arm of the M5 Manipulator, as well as its load securing device and consequently the working load can descend sharply and unexpectedly, or ascend suddenly and inappropriately after the air supply is re-established.
- ✓ If the air supply is cut off, close the main valve and move the manipulator to its retracted or parking position, ensuring that the closing device is activated.

1.4 HOOK

1.4.1 DESCRIPTION AND OPERATING PRINCIPLE

The hook-type load securing device is the perfect accessory of the M5 Manipulator for handling loads.

WARNING

- ✓ The selection and design must be made carefully for each working load.
- ✓ The integrator/end user must ensure that the load securing device is suitable for the end application.

1.4.2 OPERATIVE

WARNING

- ✓ The sequence described below supposes that the installation, settings such as the Opening of the main valve, the regulation of the supply pressure, the balancing of the arm at no load and with load, and the correct integration have been carried out following the guidelines indicated in the manual.
- ✓ Do not release the working load (low pressure) until it is resting on an appropriate, safe surface.
- ✓ Verify that the M5 Manipulator and the holding device receive compressed air before each use.
- ✓ Keep the grip surface as smooth and clean as possible.

As a passive actuator, the load securing device follows the operation sequence of the M5 Manipulator [See OPERATION page 30].