Comau Robotics
Instruction Handbook

SMART SiX

Technical Specifications

CR00757447_en-02/0406

SUMMARY

PREFACE

Symbols used in the manual

The symbols for **WARNING, CAUTION** and **NOTES** are indicated below together with their significance

This symbol indicates operating procedures, technical information and precautions that if ignored and/or are not performed correctly could cause injuries.

This symbol indicates operating procedures, technical information and precautions that if ignored and/or are not performed correctly could cause damage to the equipment.

This symbol indicates operating procedures, technical information and precautions that it are important to highlight.

Reference documents

This document refers to the SMART SiX robot with standard outfitting.

The complete set of manuals that describe the robot system and control is composed of :

Comau	Robot SMART SiX	– Technical Specifications – Transport and installation – Maintenance – Electrical diagram

These manuals are to be integrated with the following documents:

Comau	C4G Control Unit	– Technical Specifications – Transport and installation – Guide to integration, safeties, I/O and communications – Maintenance – Use of Control Unit – Electrical diagram
	Programming	– EZ PDL2 Easy programming environment – PDL2 Programming Language Manual – Move programming

1. GENERAL SAFETY PRECAUTIONS

1.1 Responsibilities

– The system integrator is responsible for ensuring that the Robot and Control System are installed and handled in accordance with the Safety Standards in force in the country where the installation takes place. The application and use of the protection and safety devices necessary, the issuing of declarations of conformity and any CE markings of the system are the responsibility of the Integrator.

– COMAU Robotics & Service shall in no way be held liable for any accidents caused by incorrect or improper use of the Robot and Control System, by tampering with circuits, components or software, or the use of spare parts that are not originals or that have not been defined as equivalent by COMAU Robotics & Service

– The application of these Safety Precautions is the responsibility of the persons assigned to direct / supervise the activities indicated in the Applicability section,They are to make sure that the Authorised Personnel is aware of and scrupulously follow the precautions contained in this document as well as the Safety Standards in addition to the Safety Standards in force in the country in which it is installed.

– The non-observance of the Safety Standards could cause injuries to the operators and damage the Robot and Control System.

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

1.2 Safety Precautions

1.2.1 Purpose

These safety precautions are aimed to define the behaviour and rules to be observed when performing the activities listed in the Applicability section.

1.2.2 Definitions

Robot and Control System
The Robot and Control System consists of all the functions that cover: Control Unit, robot, hand held programming unit and any options.

Protected Area
The protected area is the zone confined by the safety barriers and to be used for the installation and operation of the robot

Authorised Personnel
Authorised personnel defines the group of persons who have been trained and assigned to carry out the activities listed in the Applicability section.

Assigned Personnel
The persons assigned to direct or supervise the activities of the workers referred to in the paragraph above.

Installation and Putting into Service
The installation is intended as the mechanical, electrical and software integration of the Robot and Control System in any environment that requires controlled movement of robot axes, in compliance with the safety requirements of the country where the system is installed.

Programming Mode
Operating mode under the control of the operator, that excludes automatic operation and allows the following activities: manual handling of robot axes and programming of work cycles at low speed, programmed cycle testing at low speed and, when allowed, at the working speed.

Auto / Remote Automatic Mode
Operating mode in which the robot autonomously executes the programmed cycle at the work speed, with the operators outside the protected area, with the safety barriers closed and the safety circuit activated, with local (located outside the protected area) or remote start/stop.

Maintenance and Repairs
Maintenance and repairs are activities that involve periodical checking and / or replacement (mechanical, electrical, software) of Robot and Control System parts or components, and trouble shooting, that terminates when the Robot and Control System has been reset to its original project functional condition.

Putting Out of Service and Dismantling
Putting out of service defines the activities involved in the mechanical and electrical removal of the Robot and Control System from a production unit or from an environment in which it was under study.
Dismantling consists of the demolition and dismantling of the components that make up the Robot and Control System.

Integrator
The integrator is the professional expert responsible for the installation and putting into service of the Robot and Control System.

Incorrect Use
Incorrect use is when the system is used in a manner other than that specified in the Technical Documentation.

Range of Action
The robot range of action is the enveloping volume of the area occupied by the robot and its fixtures during movement in space.

1.2.3 Applicability

These Specifications are to be applied when executing the following activities:

– Installation and Putting into Service;
– Programming Mode;
– Auto / Remote Automatic Mode;
– Robot axes release;
– Stop distances (threshold values)
– Maintenance and Repairs;
– Putting Out of Service and Dismantling

1.2.4 Operating Modes

Installation and Putting into Service

- Putting into service is only possible when the Robot and Control System has been correctly and completely installed.
- The system installation and putting into service is exclusively the task of the authorised personnel.
- The system installation and putting into service is only permitted inside a protected area of an adequate size to house the robot and the fixtures it is outfitted with, without passing beyond the safety barriers. It is also necessary to check that under normal robot movement conditions there is no collision with parts inside the protected area (structural columns, power supply lines, etc.) or with the barriers. If necessary, limit the robot working areas with mechanical hard stop (see optional assemblies).
- Any fixed robot control protections are to be located outside the protected area and in a point where there is a full view of the robot movements.
- The robot installation area is to be as free as possible from materials that could impede or limit visibility.
- During installation the robot and the Control Unit are to be handled as described in the product Technical Documentation; if lifting is necessary, check that the eye-bolts are fixed securely and use only adequate slings and equipment.
- Secure the robot to the support, with all the bolts and pins foreseen, tightened to the torque indicated in the product Technical Documentation.
- If present, remove the fastening brackets from the axes and check that the fixing of the robot fixture is secured correctly.
- Check that the robot guards are correctly secured and that there are no moving or loose parts. Check that the Control Unit components are intact.
- If applicable, connect the robot pneumatic system to the air distribution line paying attention to set the system to the specified pressure value: a wrong setting of the pressure system influences correct robot movement.
- Install filters on the pneumatic system to collect any condensation.
- Install the Control Unit outside the protected area: the Control Unit is not to be used to form part of the fencing.
- Check that the voltage value of the mains is consistent with that indicated on the plate of the Control Unit.
- Before electrically connecting the Control Unit, check that the circuit breaker on the mains is locked in open position.
- Connection between the Control Unit and the three-phase supply mains at the works, is to be with a four-pole (3 phases + earth) armoured cable dimensioned appropriately for the power installed on the Control Unit. See the product Technical Documentation.
- The power supply cable is to enter the Control Unit through the specific fairlead and be properly clamped.
- Connect the earth conductor (PE) then connect the power conductors to the main switch.

– Connect the power supply cable, first connecting the earth conductor to the circuit breaker on the mains line, after checking with a tester that the circuit breaker terminals are not powered. Connect the cable armouring to the earth.

– Connect the signals and power cables between the Control Unit and the robot.

– Connect the robot to earth or to the Control Unit or to a nearby earth socket.

– Check that the Control Unit door (or doors) is/are locked with the key.

– A wrong connection of the connectors could cause permanent damage to the Control Unit components.

– The C4G Control Unit manages internally the main safety interlocks (gates, enabling pushbuttons, etc.). Connect the C4G Control Unit safety interlocks to the line safety circuits, taking care to connect them as required by the Safety standards. The safety of the interlock signals coming from the transfer line (emrgency stop, gates safey devices etc) i.e. the realisation of correct and safe circuits, is the responsibility of the Robot and Control System integrator.

In the cell/line emergency stop circuit the contacts must be included of the control unit emergency stop buttons, which are on X30. The push buttons are not interlocked in the emergency stop circuit of the Control Unit.

– The safety of the system cannot be guaranteed if these interlocks are wrongly executed, incomplete or missing.

– The safety circuit executes a controlled stop (IEC 60204-1 , class 1 stop) for the safety inputs Auto Stop/ General Stop and Emergency Stop. The controlled stop is only active in Automatic states; in Programming the power is cut out (power contactors open) immediately. The procedure for the selection of the controlled stop time (that can be set on ESK board) is contained in the Installation manual .

– When preparing protection barriers, especially light barriers and access doors, bear in mind that the robot stop times and distances are according to the stop category (0 or 1) and the weight of the robot..

Check that the controlled stop time is consistent with the type of Robot connected to the Control Unit. The stop time is selected using selector switches SW1 and SW2 on the ESK board.

– Check that the environment and working conditions are within the range specified in the specific product Technical Documentation.

– The calibration operations are to be carried out with great care, as indicated in the Technical Documentation of the specific product, and are to be concluded checking the correct position of the machine.

– To load or update the system software (for example after replacing boards), use only the original software handed over by COMAU Robotics & Service. Scrupulously follow the system software uploading procedure described in the Technical Documentation supplied with the specific product. After uploading, always make some tests moving the robot at slow speed and remaining outside the protected area.

– Check that the barriers of the protected area are correctly positioned.

Programming Mode

- The robot is only to be programmed by the authorised personnel.
- Before starting to program, the operator must check the Robot and Control System to make sure that there are no potentially hazardous irregular conditions, and that there is nobody inside the protected area.
- When possible the programming should be controlled from outside the protected area.
- Before operating inside the Protected Area, the operator must make sure from outside that all the necessary protections and safety devices are present and in working order, and especially that the hand-held programming unit functions correctly (slow speed, emergency stop, enabling device, etc.).
- During the programming session, only the operator with the hand-held terminal is allowed inside the Protected Area.
- If the presence of a second operator in the working area is necessary when checking the program, this person must have an enabling device interlocked with the safety devices.
- Activation of the motors (Drive On) is always to be controlled from a position outside the range of the robot, after checking that there is nobody in the area involved. The Drive On operation is concluded when the relevant machine status indication is shown.
- When programming, the operator is to keep at a distance from the robot to be able to avoid any irregular machine movements, and in any case in a position to avoid the risk of being trapped between the robot and structural parts (columns, barriers, etc.), or between movable parts of the actual robot.
- When programming, the operator is to avoid remaining in a position where parts of the robot, pulled by gravity, could execute downward movements, or move upwards or sideways (when installed on a sloped plane).
- Testing a programmed cycle at working speed with the operator inside the protected area, in some situations where a close visual check is necessary, is only to be carried out after a complete test cycle at slow speed has been executed. The test is to be controlled from a safe distance.
- Special attention is to be paid when programming using the hand-held terminal: in this situation, although all the hardware and software safety devices are active, the robot movement depends on the operator.
- During the first running of a new program, the robot may move along a path that is not the one expected.
- The modification of program steps (such as moving by a step from one point to another of the flow, wrong recording of a step, modification of the robot position out of the path that links two steps of the program), could give rise to movements not envisaged by the operator when testing the program.
- In both cases operate cautiously, always remaining out of the robot's range of action and test the cycle at slow speed.

Auto / Remote Automatic Mode

– The activation of the automatic operation (AUTO and REMOTE states) is only to be executed with the Robot and Control System integrated inside an area with safety barriers properly interlocked, as specified by Safety Standards currently in force in the Country where the installation takes place.

– Before starting the automatic mode the operator is to check the Robot and Control System and the protected area to make sure there are no potentially hazardous irregular conditions.

– The operator can only activate automatic operation after having checked:
  • that the Robot and Control System is not in maintenance or being repaired;
  • the safety barriers are correctly positioned;
  • that there is nobody inside the protected area;
  • that the Control Unit doors are closed and locked;
  • that the safety devices (emergency stop, safety barrier devices) are functioning;

– Special attention is to be paid when selecting the automatic-remote mode, where the line PLC can perform automatic operations to switch on motors and start the program.

Robot axes release

– In the absence of motive power, the robot axes movement is possible by means of optional release devices and suitable lifting devices. Such devices only enable the brake deactivation of each axis. In this case, all the system safety devices (including the emergency stop and the enable button) are cut out; also the robot axes can move upwards or downwards because of the force generated by the balancing system, or the force of gravity.

Before using the manual release devices, it is strongly recommended to sling the robot, or hook to an overhead travelling crane.

Stop distances (threshold values)

– As for the stop distance threshold values for each robot type, please turn to the COMAU Robotics & Service Dept.

– Example: Considering the robot in automatic mode, in conditions of maximum extension, maximum load and maximum speed, when the stop pushbutton is pressed (red mushroom head pushbutton on WiTP) an NJ 370-2.7 Robot will stop completely in approx. 85° of motion, equivalent to approx. 3000 mm displacement measured on the TCP flange. Under these conditions indicated, the stoppage time of the NJ 370-2.7 Robot is 1.5 seconds.

– Considering the robot in programming mode (T1), when the stop pushbutton is pressed (red mushroom head pushbutton on WiTP) an NJ 370-2.7 Robot will stop completely in approx. 0.5 seconds.

Maintenance and Repairs

– When assembled in COMAU Robotics & Service, the robot is supplied with lubricant that does not contain substances harmful to health, however, in some cases, repeated and prolonged exposure to the product could cause skin irritation, or if swallowed, indisposition.
First Aid. Contact with the eyes or the skin: wash the contaminated zones with abundant water; if the irritation persists, consult a doctor.

If swallowed, do not provoke vomiting or take anything by mouth, see a doctor as soon as possible.

– Maintenance, trouble-shooting and repairs are only to be carried out by authorised personnel.

– When carrying out maintenance and repairs, the specific warning sign is to be placed on the control panel of the Control Unit, stating that maintenance is in progress and it is only to be removed after the operation has been completely finished - even if it should be temporarily suspended.

– Maintenance operations and replacement of components or the Control Unit are to be carried out with the main switch in open position and locked with a padlock.

– Even if the Control Unit is not powered (main switch open), there may be interconnected voltages coming from connections to peripheral units or external power sources (e.g. 24 Vdc inputs/outputs). Cut out external sources when operating on parts of the system that are involved.

– Removal of panels, protection shields, grids, etc. is only allowed with the main switch open and padlocked.

– Faulty components are to be replaced with others having the same code, or equivalent components defined by COMAU Robotics & Service.

After replacement of the ESK module, check on the new module that the setting of the stop time on selector switches SW1 and SW2 is consistent with the type of Robot connected to the Control Unit.

– Trouble-shooting and maintenance activities are to be executed, when possible, outside the protected area.

– Trouble-shooting executed on the control is to be carried out, when possible without power supply.

– Should it be necessary, during trouble-shooting, to intervene with the Control Unit powered, all the precautions specified by Safety Standards are to be observed when operating with hazardous voltages present.

– Trouble-shooting on the robot is to be carried out with the power supply cut out (Drive off).

– At the end of the maintenance and trouble-shooting operations, all deactivated safety devices are to be reset (panels, protection shields, interlocks, etc.).

– Maintenance, repairs and trouble-shooting operations are to be concluded checking the correct operation of the Robot and Control System and all the safety devices, executed from outside the protected area.

– When loading the software (for example after replacing electronic boards) the original software handed over by COMAU Robotics & Service is to be used. Scrupulously follow the system software loading procedure described in the specific product Technical Documentation; after loading always run a test cycle to make sure, remaining outside the protected area

– Disassembly of robot components (motors, balancing cylinders, etc.) may cause uncontrolled movements of the axes in any direction: before starting a disassembly procedure, consult the warning plates applied to the robot and the Technical Documentation supplied.

– It is strictly forbidden to remove the protective covering of the robot springs.

Putting Out of Service and Dismantling

– Putting out of service and dismantling the Robot and Control System is only to be carried out by Authorised Personnel.

– Bring the robot to transport position and fit the axis clamping brackets (where applicable) consulting the plate applied on the robot and the robot Technical Documentation.

– Before stating to put out of service, the mains voltage to the Control Unit must be cut out (switch off the circuit breaker on the mains distribution line and lock it in open position).

– After using the specific instrument to check there is no voltage on the terminals, disconnect the power supply cable from the circuit breaker on the distribution line, first disconnecting the power conductors, then the earth. Disconnect the power supply cable from the Control Unit and remove it.

– First disconnect the connection cables between the robot and the Control Unit, then the earth cable.

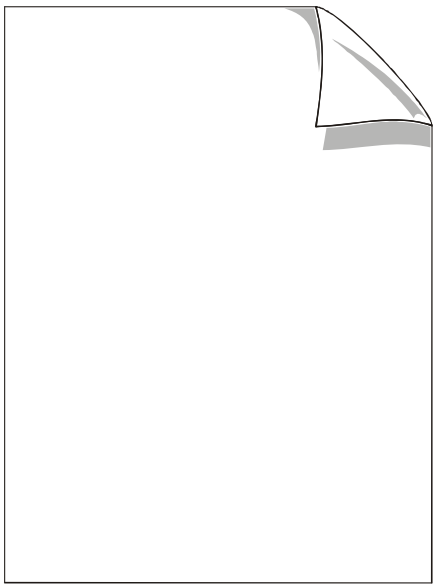
– If present, disconnect the robot pneumatic system from the air distribution line.

– Check that the robot is properly balanced and if necessary sling it correctly, then remove the robot securing bolts from the support.

– Remove the robot and the Control Unit from the work area, applying the rules indicated in the products Technical Documentation; if lifting is necessary, check the correct fastening of the eye-bolts and use appropriate slings and equipment only.

– Before starting dismantling operations (disassembly, demolition and disposal) of the Robot and Control System components, contact COMAU Robotics & Service, or one of its branches, who will indicate, according to the type of robot and Control Unit, the operating methods in accordance with safety principles and safeguarding the environment.

– The waste disposal operations are to be carried out complying with the legislation of the country where the Robot and Control System is installed.



2. GENERAL DESCRIPTION

2.1 Robot SMART SiX

SMART SiX is the COMAU family of robots designed to address applications such as light-duty handling and arc welding.

The main robot characteristics are listed below:
– pre-engineered for use with a variety of optional devices;
– oil lubrication for all the reducers, with the exception of axes 5 and 6 which are lubricated with grease,
– possibility of connecting electrical and pneumatic services to the forearm;
– reduced wrist dimensions enable high capacity orientation in small spaces;
– high repeatability;
– robot protection level is IP65
– no specific devices for axis compensation.

The handling of the axes is controlled by brushless motors with direct transmission of the motion to axes 1-2-3-4, by means of mechanical geared reduction units, whereas for axes 5-6 the transmission is by belt to a Harmonic Drive type reduction unit.

The main robot fittings include:
– a specific welding dressing;
– an internal pneumatic line with upper connection on the back of the forearm;
– wiring that comprises a service line with a connector on the upper plate next to the pneumatic connection;
– flat surfaces and threaded holes on the upper part of the forearm that can be used to assemble fixtures (servovalves, transformer, etc.);

A specific outfitting is available with the SMART SiX robot for arc welding, including the welding wire coil, wire-puller, torch and equipment on the robot.

Fig. 2.1 - SMART SiX

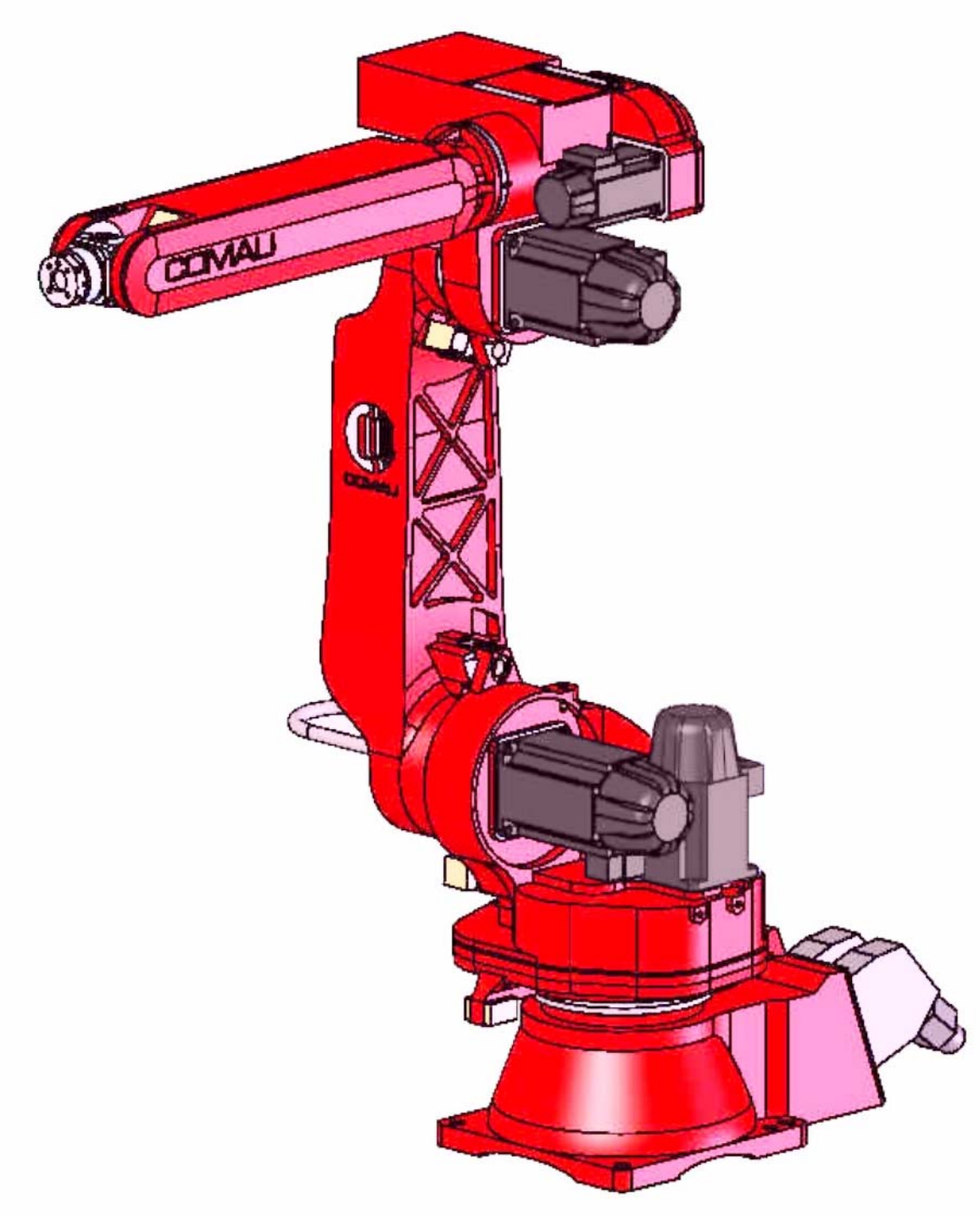
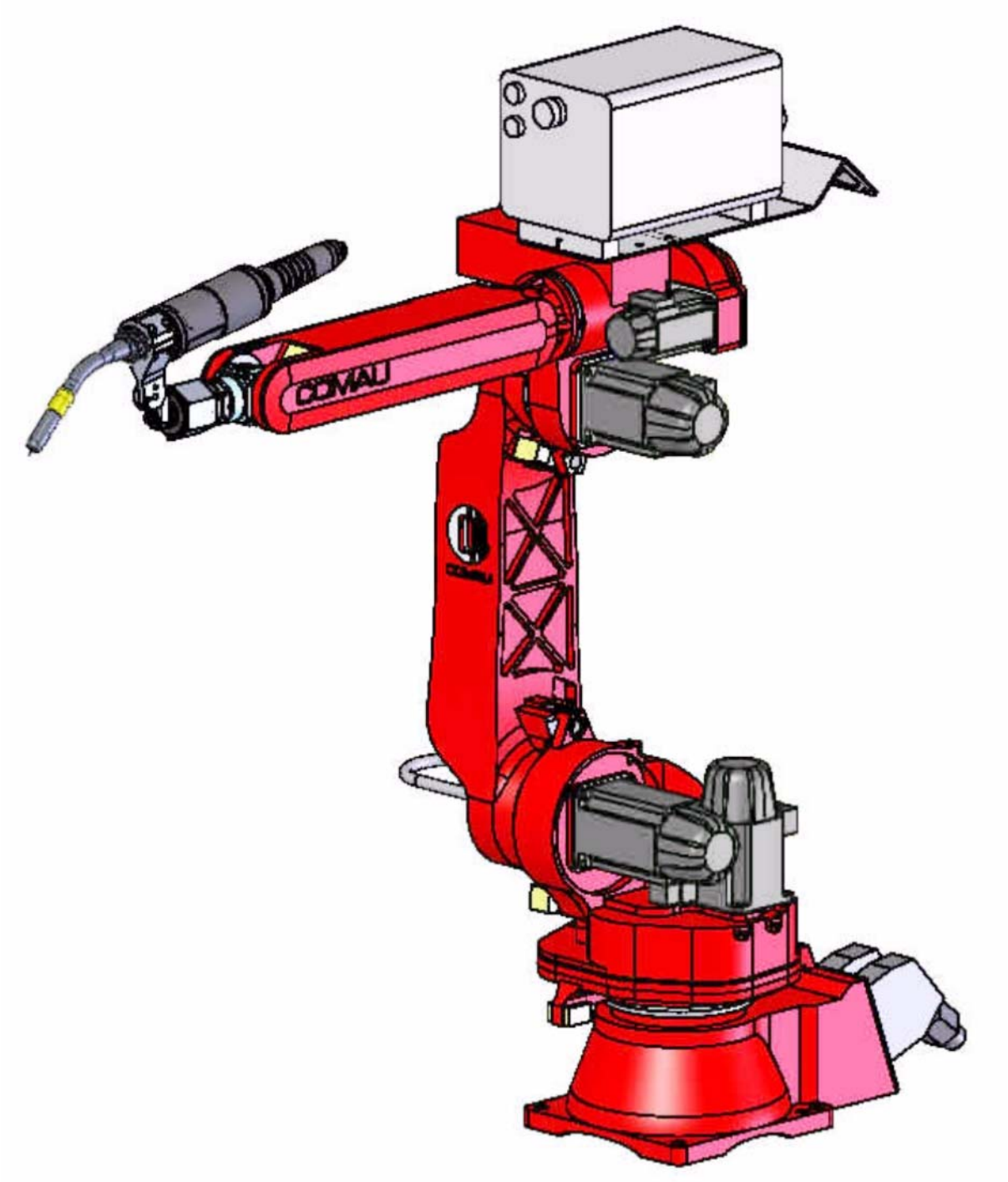


Fig. 2.2 - SMART SiX ARC



For all models and versions, the loads indicated (at wrist and additional) can be moved to maximum performance within the entire working range by means of specific software that, by allowing maximum speeds to be reached in applications where the robot strokes are sufficiently wide, permits maximum accelerations according to the load declared and the cycle.
The design has been optimized by using three-dimensional CAD applications, and the structures have been dimensioned by means of finite element analysis (FEA); this has given excellent results in performance and reliability.

The attention to detail has resulted in a machine that is user-friendly in daily use, reducing the number of parts and facilitating access for servicing.

Robots require little maintenance, which is intuitive and does not require the use of any special equipment.

Interchangeability between robots of the same version is ensured: a robot can be replaced quickly without any complex corrective operations on the program.

Each robot is equipped with a Control System that conforms to European Union safety standards and all the other most important standards.

Connection cables between the control and the robot have "plug-in" connectors.

Safety is guaranteed by the availability of a series of optional equipment in compliance with the most severe European and international standards.

2.2 Robot mechanical features

The robot consists of an anthropomorphic structure with 6 degrees of freedom.

It is anchored to the floor by means of a steel plate and bolts. Alternatively we can supply an optional assembly consisting of a plate that is fastened to the robot by means of screws and four plates that are inserted underneath these and anchored to the floor by means of bolts that are welded to the plate. The plate has four screws that can be used to level the robot.

The robot has a fixed base on which the column with the axis 2 gear reducer rotates around the vertical axis (axis 1).

An arm connects axis 2 to the forearm and includes the reducers of axes 3-4-5-6; the wrist is located at the end of the forearm.

The robot axes are equipped with software limit stop (programmable) and /or mechanical shock absorber stops supplied as standard or on request; the strokes of the main axes (axes 1-2-3) can be limited by means of additional mechanical shock absorber stops, according to specific application requirements.

Tab. 2.1 - Limit stops available

Robot Model	Standard		Optionals
	Software limit stop	Mechanical hard stop	Movable mechanical hard stop
SMART SiX	All axes	1-2-3-4-5	1-2

The reducers are of the type with zero clearance, specifically designed for robot applications.

To give better efficiency, the reduction units are lubricated with oil, except for axes 5

and 6 which are lubricated with grease ; the oil only requires changing every 15,000 h, equivalent to approx. 3 years of operation over three working shifts.

The motors are of the AC brushless type and incorporate the brake and encoder.

2.3 Interchangeability

The interchangeability of robots of the same version is a fundamental characteristic to enable rapid substitution, or to transfer the same program onto another robotic station.

This characteristic is guaranteed by:

– adequate construction tolerances of all the parts that make up the structure

– precise robot location on the mounting plate by means of two pins (supplied with the robot)

– possibility of bringing the axes to a known position (Calibration) using a specific tool (the same for all models)

These features make it possible to transfer programs between robots of the same version.

The above-mentioned characteristics are indispensable for effective “off-line programming” executed in virtual environment.

2.4 Calibration

Calibration is the operation that makes it possible to bring the robot axes to a known position to ensure the correct repetition of programmed cycles and interchangeability between machines of the same version.

There are two calibration methods:

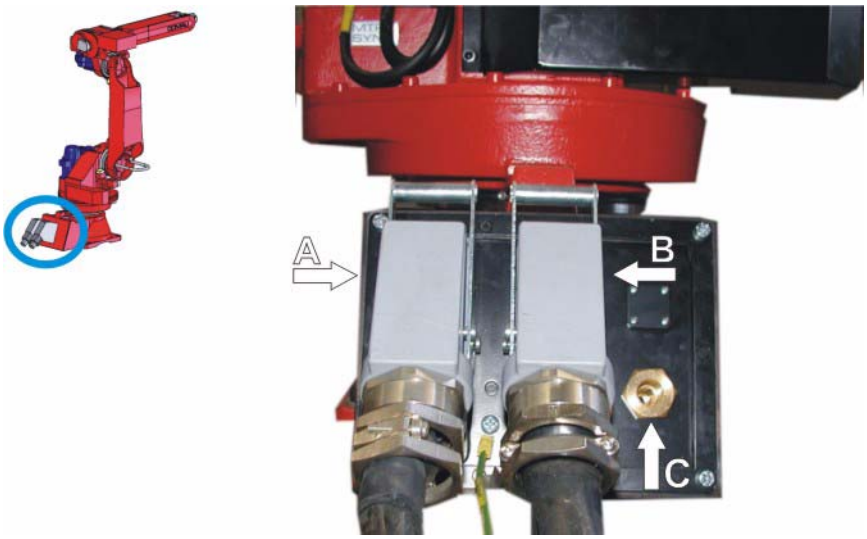
– precise calibration: executed using a special tool. This operation must be executed after special maintenance operations involving the separation of the kinematic chain between the motor and the robot axis, or when particularly demanding cycles regarding precision have to be executed.

– calibration using location notches enables rapid but improper calibration with less precision, and it may not restore robot movements with the precision that is required by the specific application. Calibration by notches consists of bringing the robot axes onto the calibration notches, aligning them with precision by sight, without using specific tools, executing the calibration commands axis by axis.

2.5 Pneumatic and electrical services

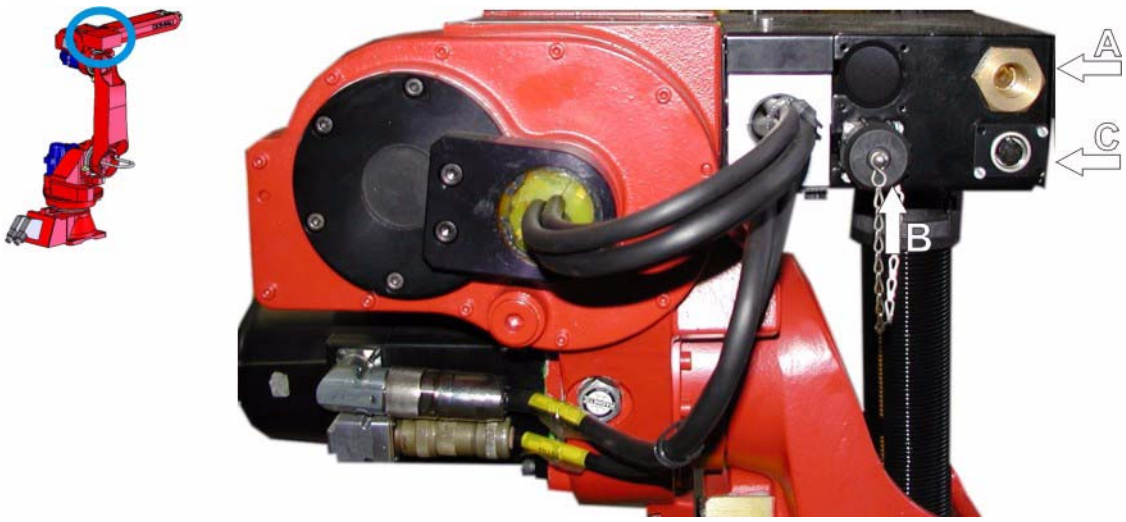
Each robot has an internal pneumatic line and connections for optional electric services as shown in the following figures:

Fig. 2.3 - Distribution at robot base



Position	Description
A	Connector X1 services / encoder
B	Connector X2 motors
C	Compressed air inlet, AIR pipe union

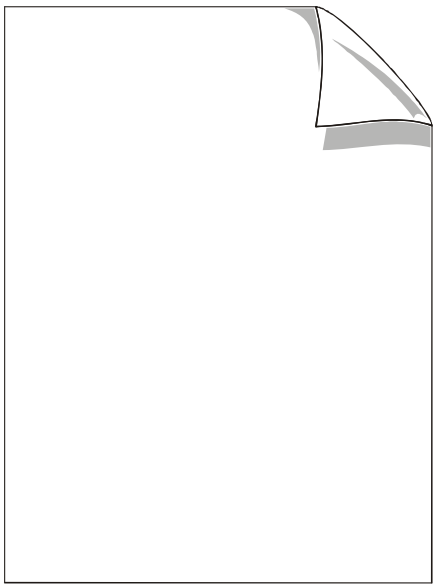
Fig. 2.4 - Upper distribution on robot forearm



Position	Description
A	Connector X91 services (I/O on board robot) available for the user
B	Connector X92 for safety flange connection
C	AIR1 pipe union, not used, available for the user

For the assembly of the pneumatic line fittings (located at the side of the distribution assembly and on the upper part of the forearm) the robot is provided with two 3/8" threaded holes.
On the upper distribution there are two electric connectors : X91 for optional services and X92 for the safety flange connection.

For further details regarding the connection, see the chapter " Integration with Control Unit and external devices" in the Transport and Installation manual.



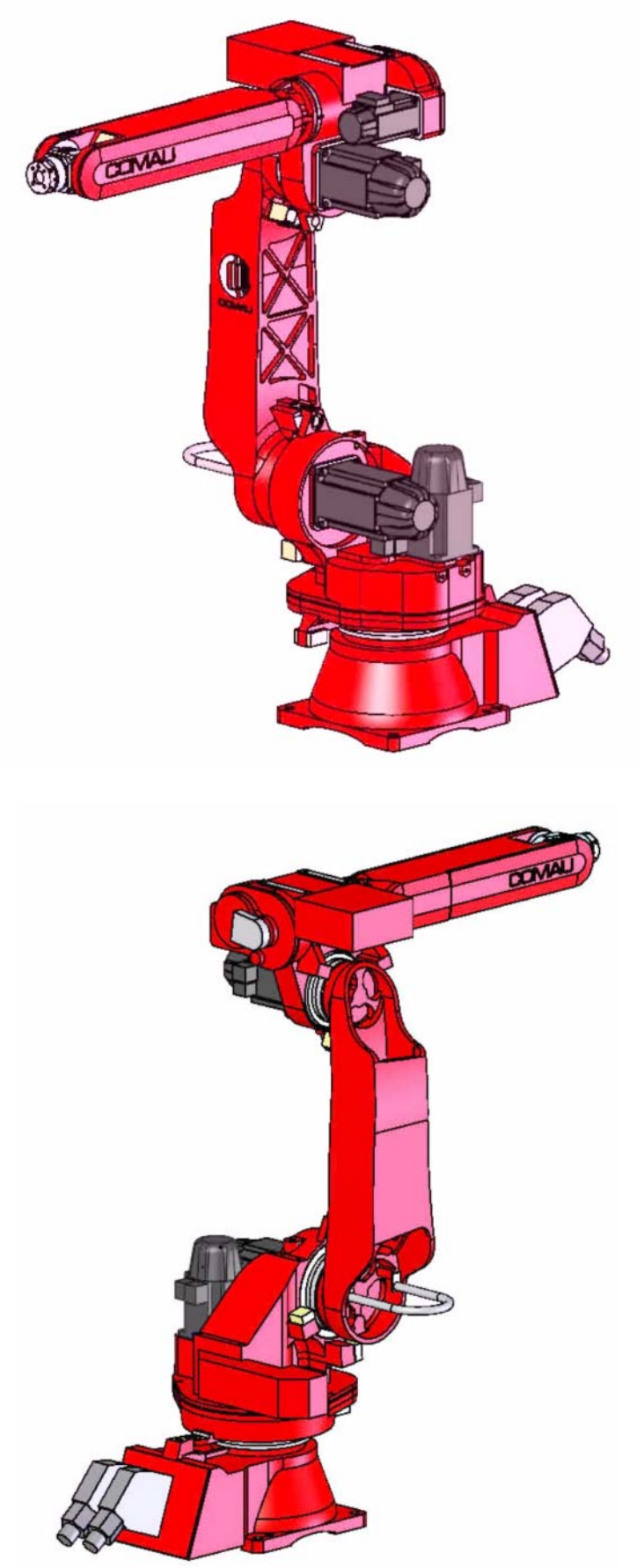
3. TECHNICAL CHARACTERISTICS

3.1 Overview

This chapter contains views and characteristics of the available SMARTSiX robots.

The working volume and the overall dimensions of all available robots are contained in Chap.4. - Operating Areas and Robot Overall Dimensions

Fig. 3.1 - SMART SiX 6-1.4 general view

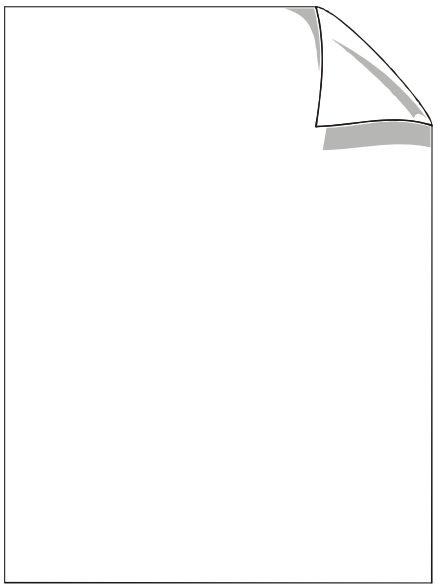


Tab. 3.1 - Characteristics and performance

VERSION		SIX 6-1.4
Structure / n° axes		Anthropomorphous / 6 axis
Load at wrist		6 kg(1) *16.08 lb*
Additional load on forearm		10 kg(2) *26.79 lb*
Torque axis 4		11,7 Nm
Torque axis 5		11,7 Nm
Torque axis 6		5,8 Nm
Stroke / (Speed)	Axis 1	+/- 170°(140°/s)
	Axis 2	+155°/-85°(160°/s)
	Axis 3	0°/-170°(170°/s)
	Axis 4	+/-210°(450°/s)
	Axis 5	+130°/-130°(375°/s)
	Axis 6	+/- 2700°(550°/s)
Maximum horizontal reach		1400 mm *55.12 in*
Repeatability		+/- 0,05 mm *+/- 0.1968 in*
Robot weight		160 kg *428.67 lb*
Tool coupling flange		ISO 9409-1-40-4-M6
Motors		AC brushless
Position measurement system		with encoder
Total power installed		3 kVA / 4,5 A
Protection class		IP65
Working temperature		0 ÷ + 45 °C
Storage temperature		-40 °C ÷ +60 °C
Colour of robot (standard)		Red RAL 3020
Assembly position		Floor Ceiling Tilted (45°)

(1) See Chap.6. - Loads at Wrist and Additional Loads par. 6.2 Determination of max loads at wrist flange (QF) on page 6-2

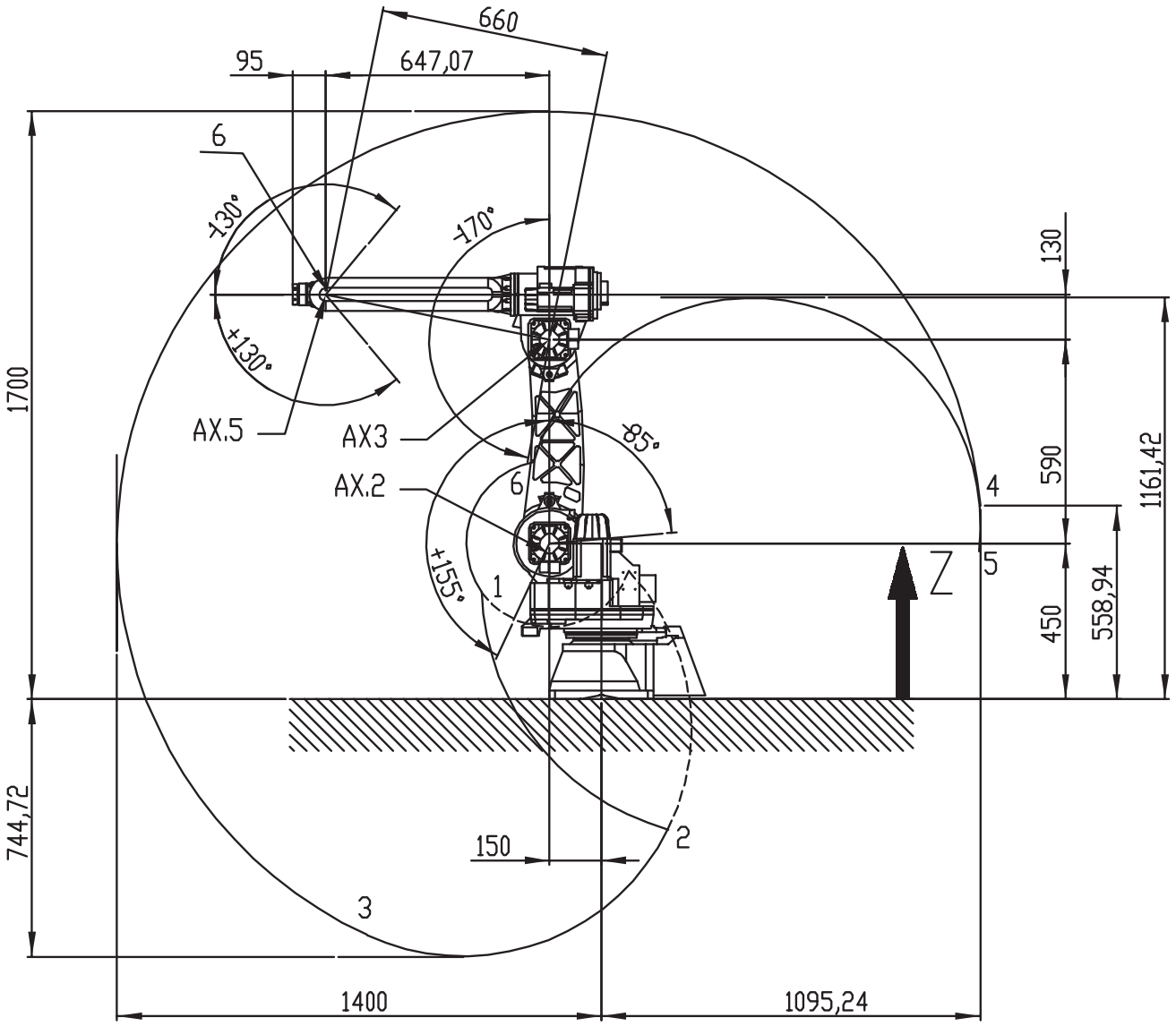
(2) See Chap.6. - Loads at Wrist and Additional Loads par. 6.3 Additional loads (QS) on page 6-4

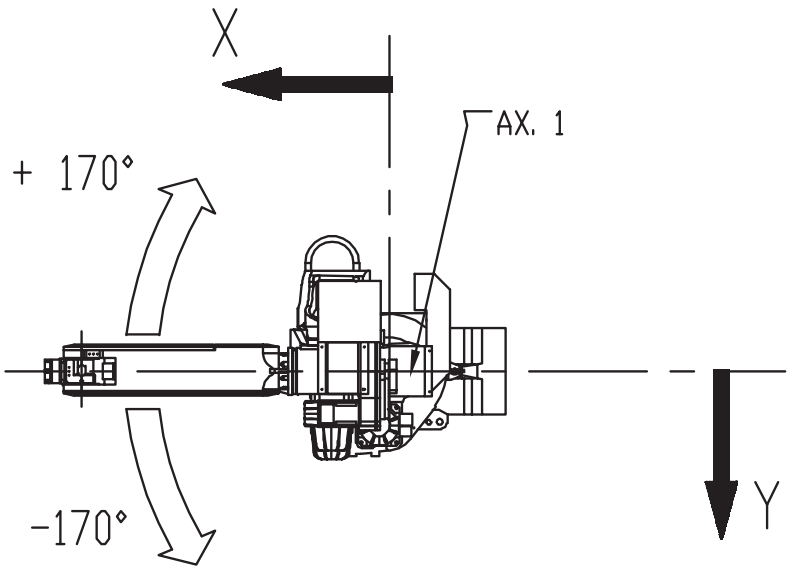


4. OPERATING AREAS AND ROBOT OVERALL DIMENSIONS

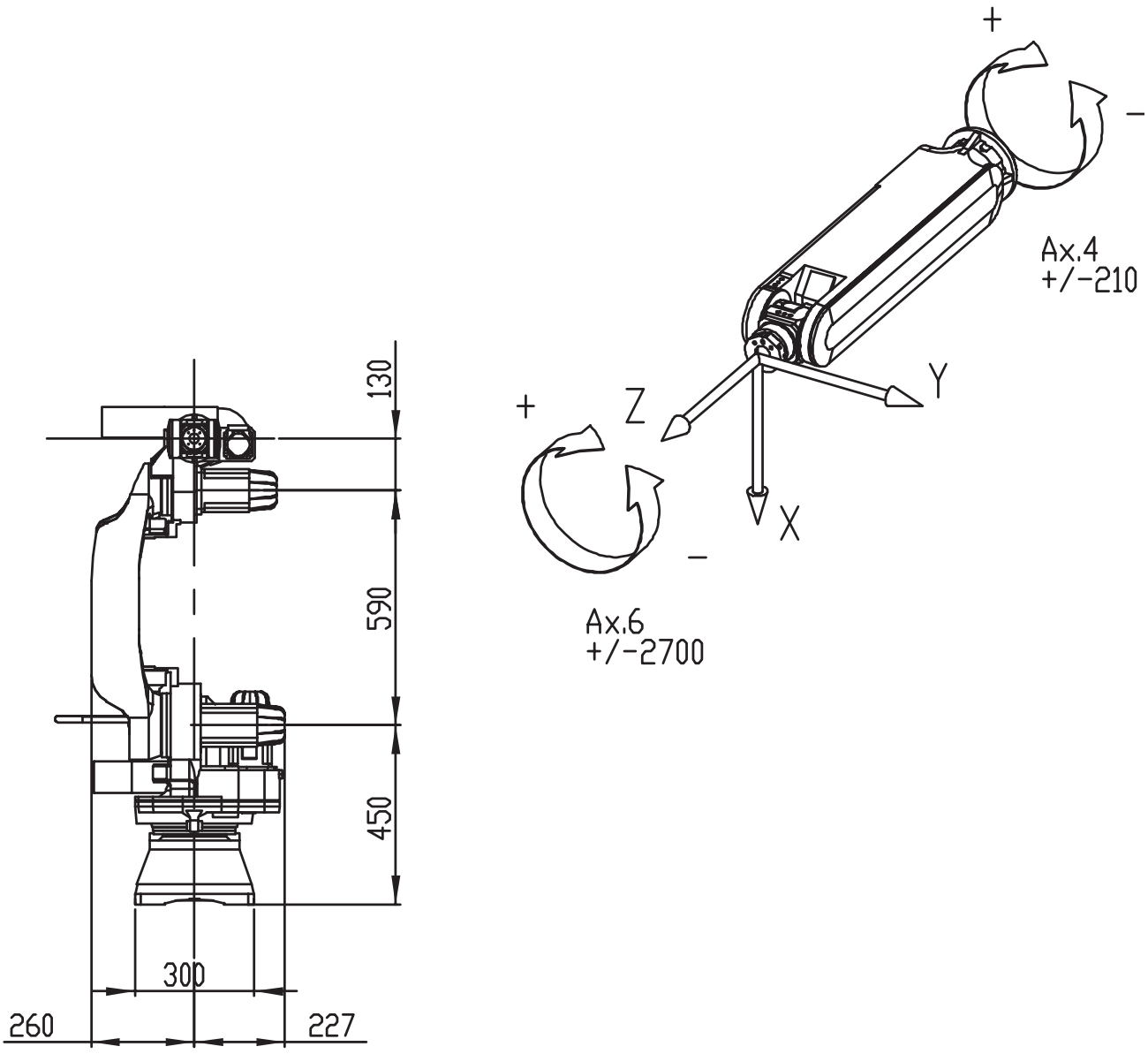
This chapter describes the operating area and the overall dimensions of the SMART SiX robot. It also contains the drawings listed below:

SMART SiX 6-14 Operating area





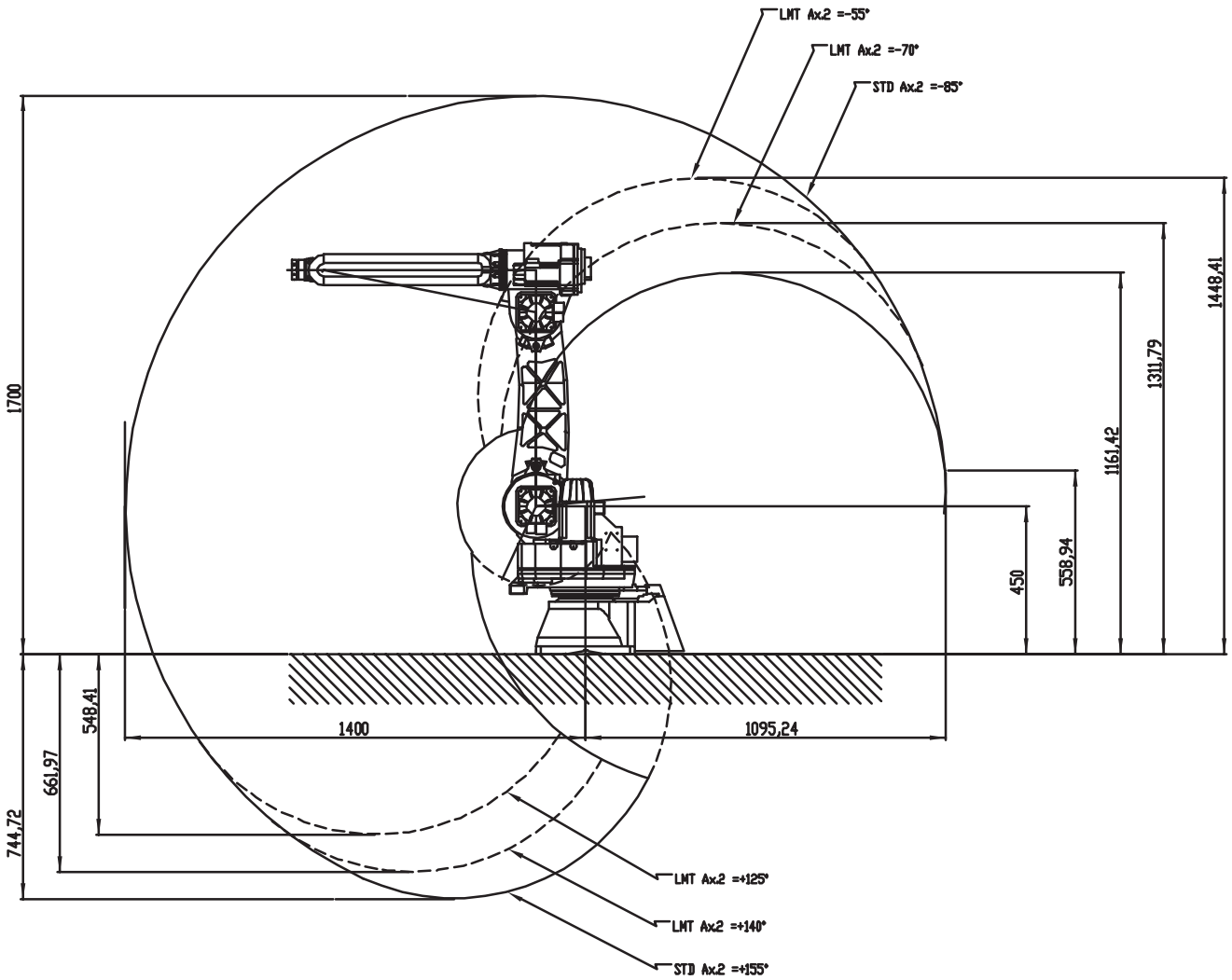
SMART SiX 6-14 Operating area



Pos	X	Z	Ax.2	Ax.3
	[mm]	[mm]	[deg]	[deg]
1	345,85	308,45	+30°	-170°
2	-192,03	-377,77	+155°	-100°
3	678,27	-682,88	+155°	-11,36°
4	-1095,24	558,94	-85°	-11,36°
5	-1093,69	428,31	-85°	0°
6	45,45	687,32	-85°	-170°

Joints in calibration position (pos.7)					
Ax 1	**Ax 2**	**Ax 3**	**Ax 4**	**Ax 5**	**Ax 6**
0°	0°	-90°	0°	+90°	0°

SMART SiX 6-14 Operating area boundary



LMT = Operation area with axes limits
STD = Standard operating area

5. ROBOT FLANGE

5.1 Fixture mounting flange

This chapter contains the drawings of the fixtures mounting flanges with dimensions and centre distances of the holes for the fixture mounting).
The flange is shown with the Gauged Tool option. This option is used to calculate the exact flange center point when installing tools.

Fig. 5.1 - Fixture mounting flange and calibrated fixture

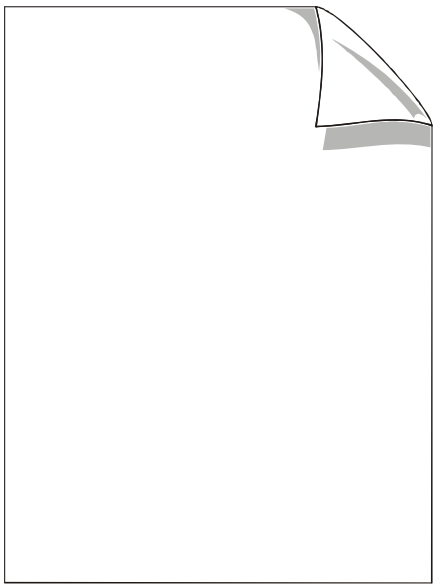
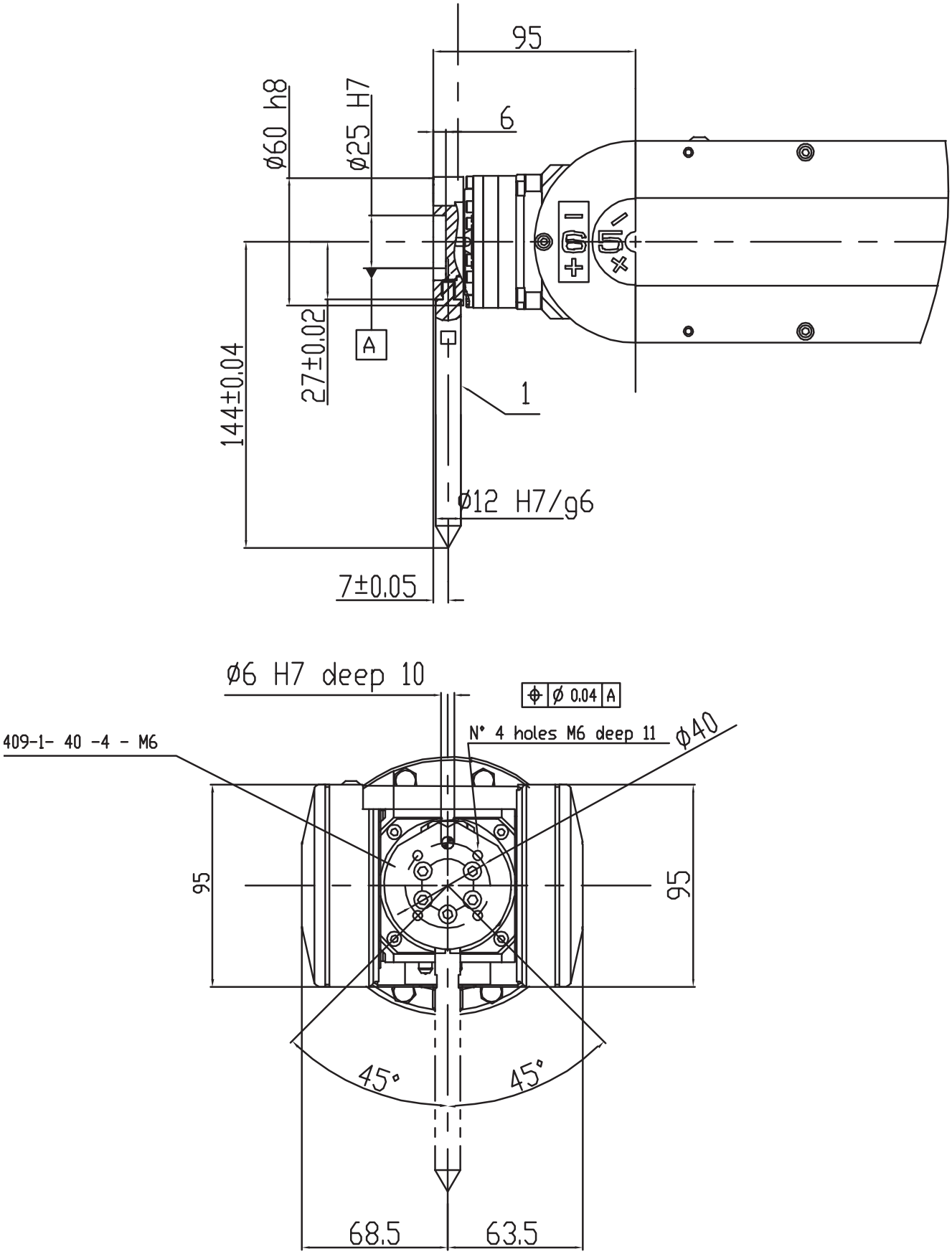
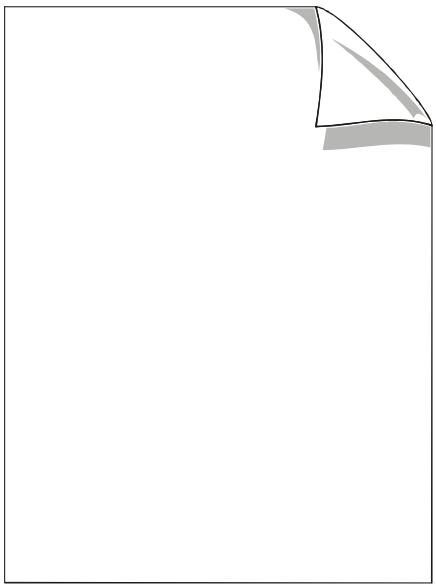


Fig. 5.1 - Fixture mounting flange and calibrated fixture



1. Calibrated fixture (code 81783801)



6. LOADS AT WRIST AND ADDITIONAL LOADS

6.1 Overview

This chapter describes the procedures to determine:

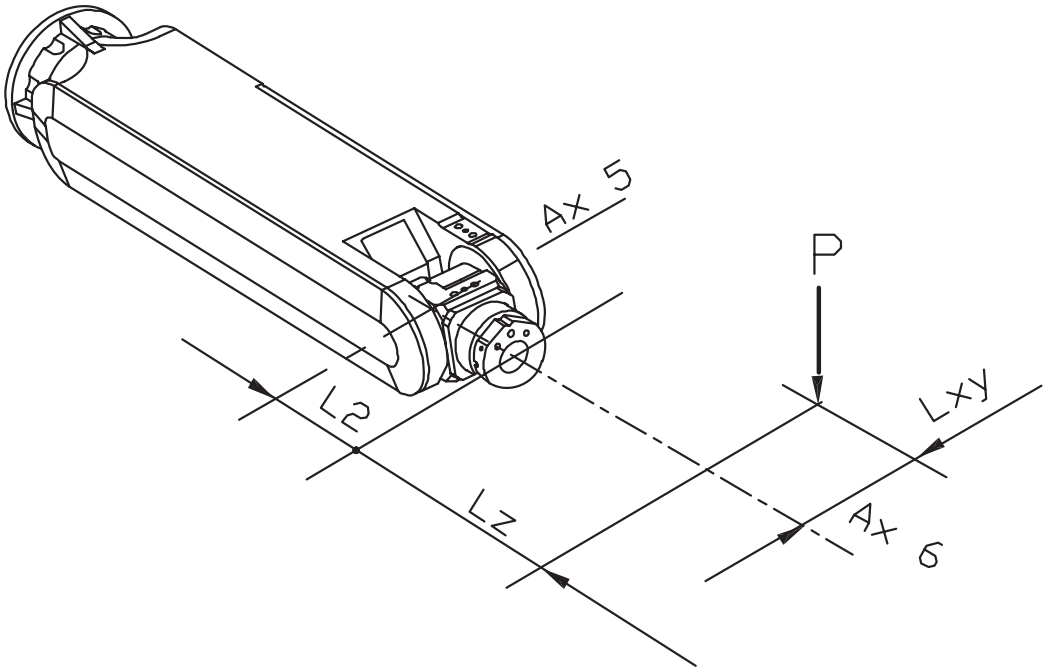
– Load capacity on the flange according to the distance from the centre of gravity
  • Fig. 6.3 - SMART SiX Maximum load capacity of the flange

– Areas in which the centre of gravity position related to additional load is allowed
  • Fig. 6.4 - Additional loads centre of gravity positioni

– Centre distances and dimensions of holes to fasten any fixtures applied on the robot forearm
  • Fig. 6.5 - Holes for connecting tools to the forearm

Abbreviations
In this chapter the following abbreviations have been used:
- Q_F =Max. load applied to the flange;
- Q_S = Additional load applied to the forearm;
- Q_T =Max total load applied on the robot;
- Lz = distance of load P centre of gravity from the flange axis;
- Lxy = distance of load P centre of gravity from axis 6
- L_2 = distance of axis 5 from fixture mounting flange (see diagram)

Fig. 6.1 - Centre of gravity co-ordinates of the applied load

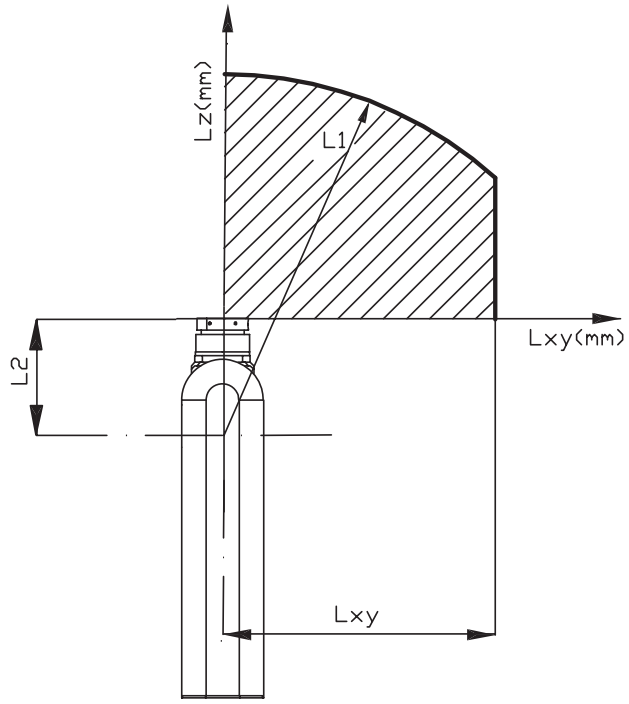


6.2 Determination of max loads at wrist flange (Q_F)

The maximum load that can be applied to the flange is defined using the wrist load graphs, where the curves of maximum load Q_F are plotted according to co-ordinates L_Z and L_{XY} of the load centre of gravity.

The area below the load curve defines centre of gravity distances allowed for the application of the load indicated on it.

Fig. 6.2 - Notes for the load graphics definition



For load or inertia values that differ from those indicated in the graphs, a specific curve can be plotted using these formulas:

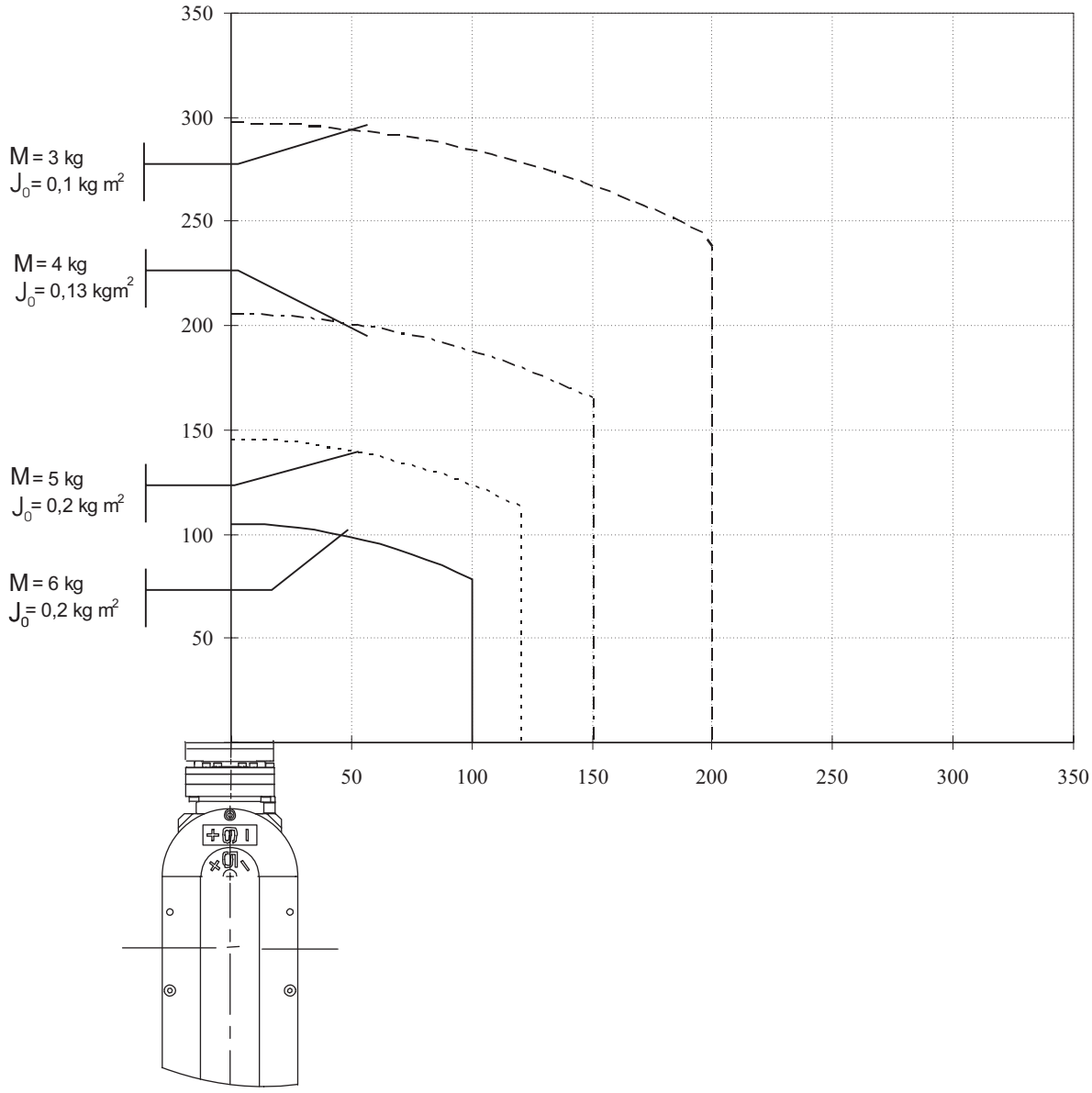
$Kz = (a - 0{,}25 \times J_0) / M$
$L_1 = 2000 [- b + (c + Kz)^{0,5}]$
$Kxy = (d - 0{,}25 \times J_0) / M$
$Lxy = 2000 [- e +(f + Kxy)^{0,5}]$

where:

- a, b; c; d; e; f = numeric constants depending on the type of wrist (see Load Capacity graphs).
- J_0 (kgm^2) = maximum centre of gravity moment of inertia of the total load applied to the flange
- M (kg) = total weight applied to the flange
- L_2 = L_1 curves centre position corresponding to the distance of the flange from axis 5 (see diagram)

In any case the following conditions must be checked: $L_1 \leq H / M$; $Lxy \leq N / M$
where: H and N = numeric constant according to the type of wrist

Fig. 6.3 - SMART SiX Maximum load capacity of the flange



Numeric constants to be applied to the formulas contained in Determination of max loads at wrist flange (QF)
a=0,372; b=0,198; c=0,039; d=0,154; e=0,128; f=0,0016;
H=1200; N=600; L_2 = 95 mm

The inertia specified in the graph curves refers to the centre of gravity of the load applied on the flange.

6.3 Additional loads (Q_S)

It is possible to apply an additional load Q_S on the forearm, besides the load on the flange Q_F, for all the robots, except the SH versions. The values of these loads are indicated in Tab. 6.1 - Maximum applicable loads.

In each application, the centre of gravity of the load applied on flange Q_F is to be within the area subtended by the curves of following graphs in Fig. 6.3 - SMART SiX Maximum load capacity of the flange. Furthermore the centre of gravity of additional load Q_S has to be within the area of the graph shown in Fig. 6.4 - Additional loads centre of gravity positioni.

For the installation of special fixtures on the robot, the holes can be used in the robot forearm, shown in Fig. 6.5 - Holes for connecting tools to the forearm

Tab. 6.1 - Maximum applicable loads

Max. total load	SMART SiX
Max overall load that can be applied on robot QT	16 kg
Load on the flange Q_F	6 kg
Additional load on forearm Q_S	10 kg

Fig. 6.4 - Additional loads centre of gravity positioni

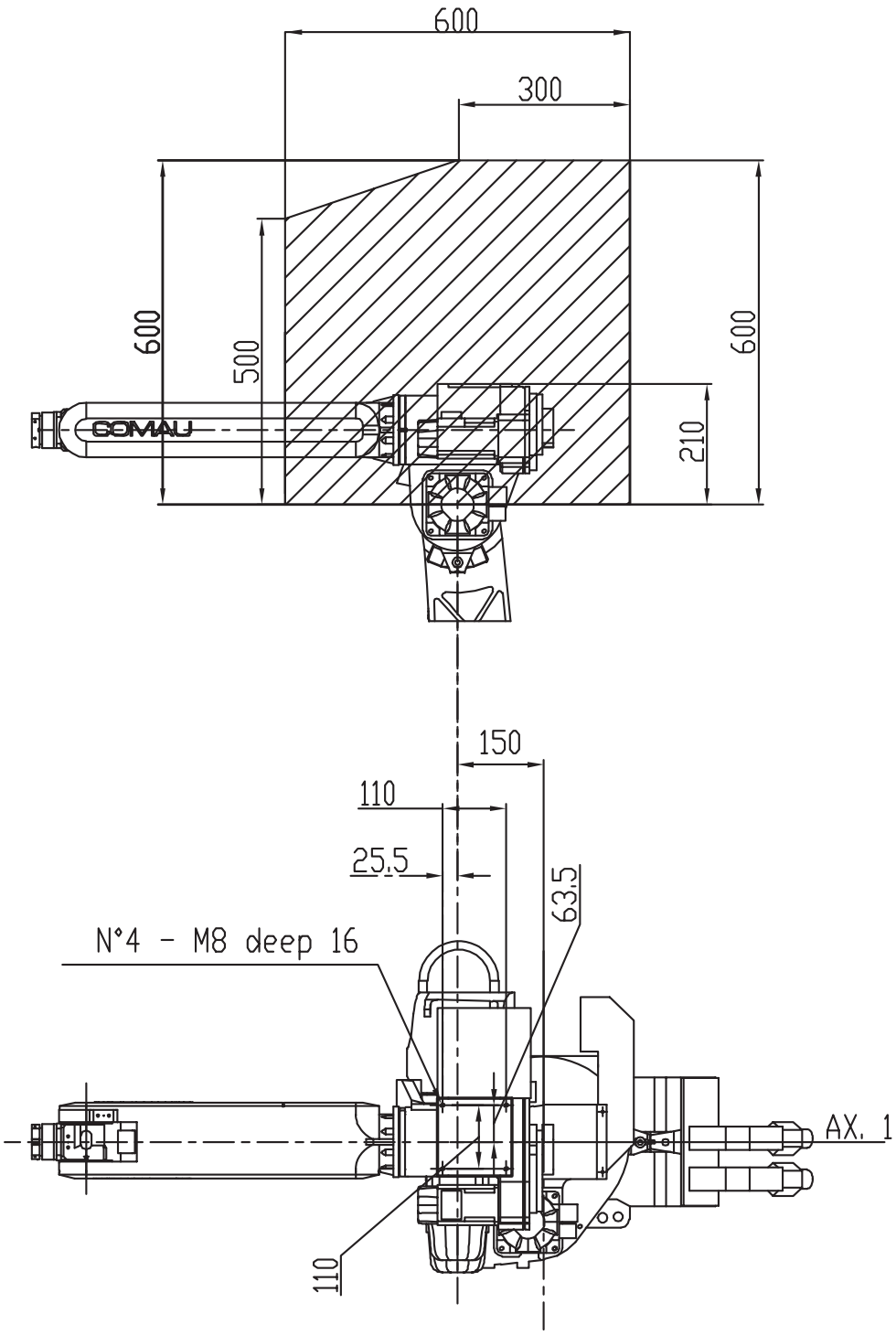
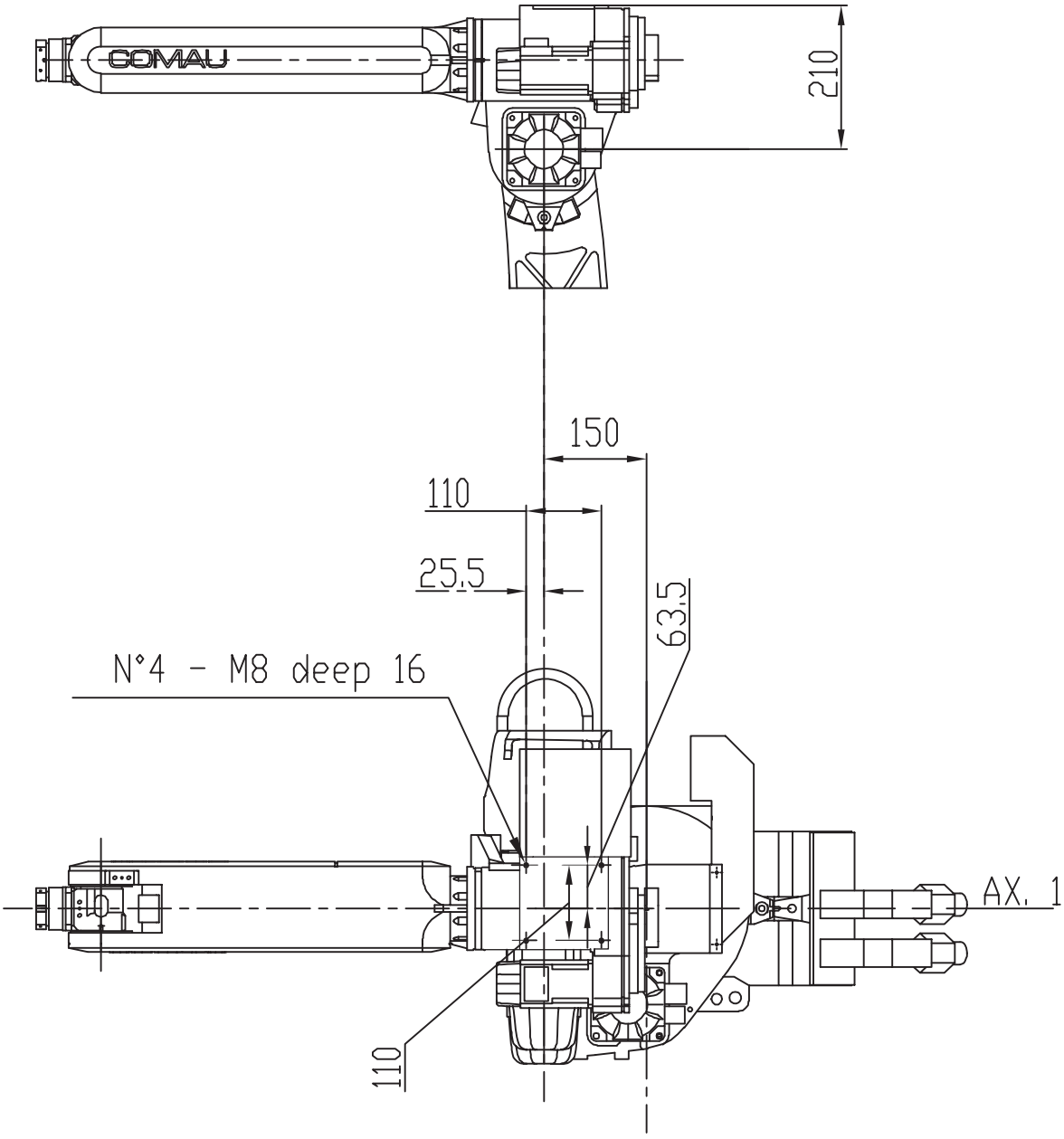


Fig. 6.5 - Holes for connecting tools to the forearm



7. PREPARATION FOR ROBOT INSTALLATION

Before carrying out any type of installation operation carefully read Chap.1. - General Safety Precautions.

The robot has to be coupled to the C4G Control Unit. No other use is permitted. Any exceptions are to be explicitly authorised by COMAU.

7.1 Environment conditions

The environment for robot use is the usual workshop environment.

The robot wrist is manufactured to a high protection standard (IP67) so that it is suitable for applications in aggressive dusty environments.
The robot can be installed on a horizontal plane (see par. 7.2 Robot installation on horizontal plane on page 7-1 or on a sloped plane taking into account opportune restrictions (see par. 7.3 Installing the robot on a sloping surface on page 7-8).

7.1.1 Environment data

- Operating environment temperature: 0°C ÷ 45°C
- Relative humidity: 5% ÷ 95% without condensation.
- Storage environment temperature: -40 °C ÷ 60 °C.
- Maximum temperature gradient: 1,5 °C/min.

7.1.2 Operating space

The maximum overall dimensions of the operating area from the centre of the wrist are shown in the graphs in Chap. OPERATING AREA AND ROBOT OVERALL DIMENSIONS.

7.2 Robot installation on horizontal plane

Due to the considerable stress discharged to the ground by the robot, securing the robot directly on the floor is not envisaged.

7.2.1 Attachment to a steel plate

The robot has to be secured to a steel plate, installed on the floor and provided with the holes for the pins and screws for the robot anchorage.

To secure the robot to the plate, an optional Robot-base attachment screws and pins is available, illustrated in Fig. 7.1.

The values of the stress discharged to the ground by the robot, to be taken into account for the dimensioning of the plate, are indicated in Fig. 7.3 - Stress at ground level generated by robot.

The foundation where the robot is installed is not to be influenced by vibrations coming from other machines (for example sledge hammers, presses, etc.).

7.2.2 Attachment to a plate with adjustable level (optional)

To secure the robot an optional assembly can be used, consisting of 4 plates secured to the ground and a steel plate secured to the robot that can be levelled by means of special screws (see Fig. 7.2 - Level adjustment plate). To secure the plates to the ground the recommended components (not supplied) are listed in Tab. 7.1 - Components recommended to secure the level adjustment plates to the floor.

Tab. 7.1 - Components recommended to secure the level adjustment plates to the floor

Component	Reference	Code	Hole Depth Diameter	Qty
Chemical capsule	HILTI	HVU M16x125	Ø 16x 125 mm	8
Pin	HILTI	HAS M16x125/38 C **inst** = 120Nm		

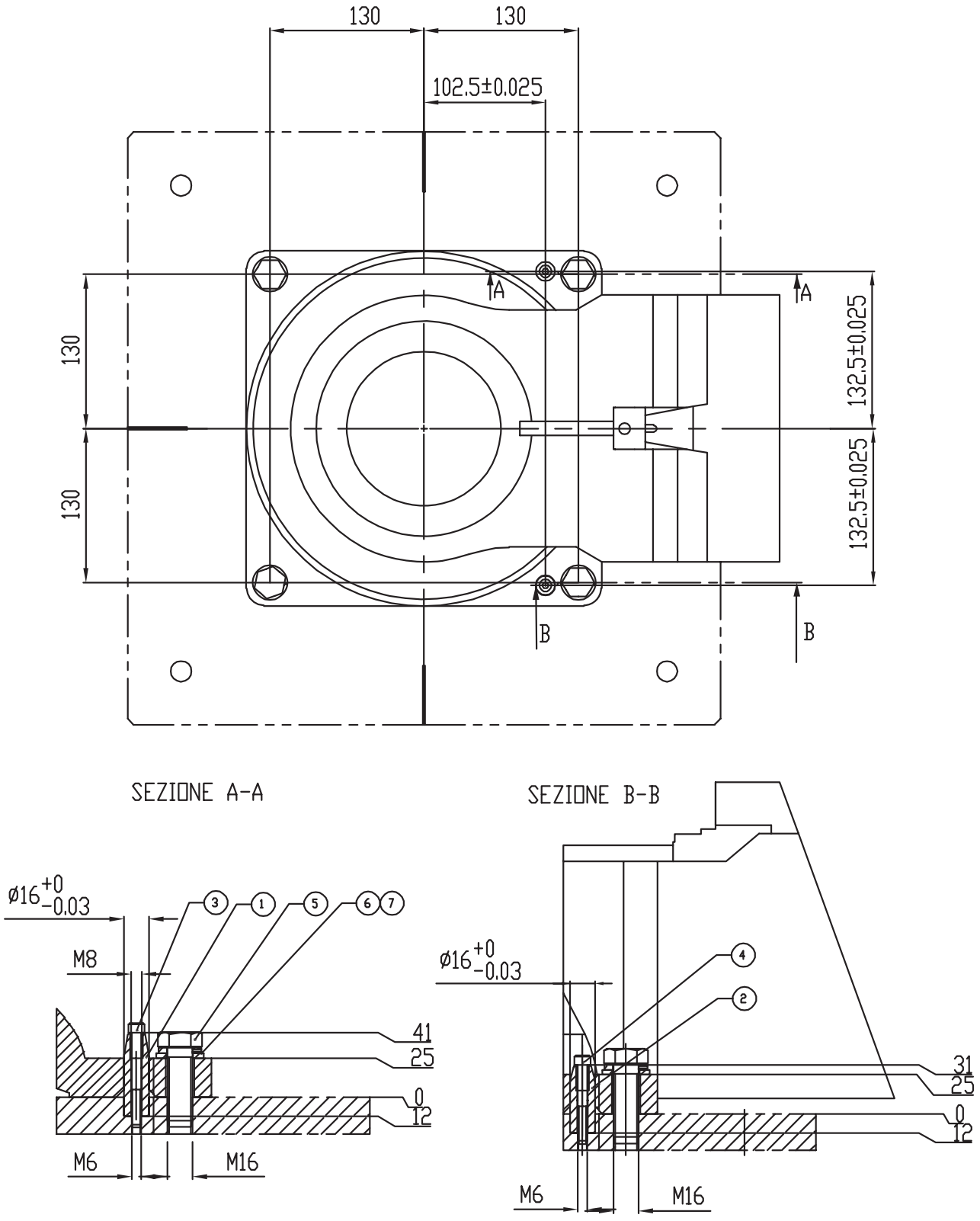
To avoid any micro movements of the plate caused by repeated alternated stresses generated by the robot during normal work cycles, lay the plate on a layer of aligning mortar specifically for metal on concrete applications.

7.2.3 Installation on raised support (optional)

If the robot is to be installed on a raised surface, the optional assembly shown in Fig. 7.4 - Raised support with horizontal plane can be used. It is available with three different heights and each has its own code.

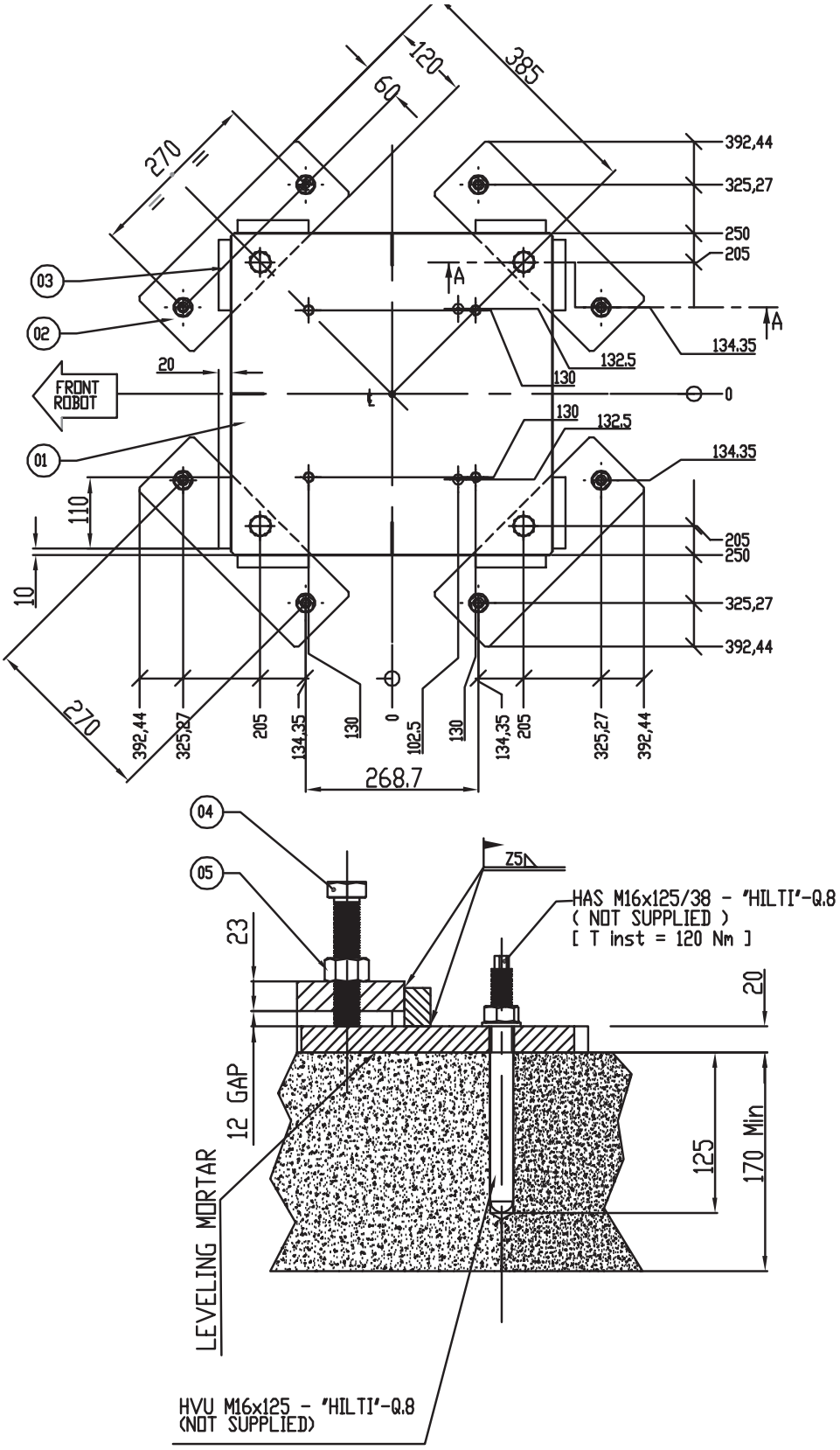
The stress discharged to the ground by the robot when a raised support is used is indicated in Fig. 7.5 - Stress to ground generated by robot secured on a raised support with horizontal plane. The support can be secured directly on the floor using the specific chemical components (see Tab. 7.1 - Components recommended to secure the level adjustment plates to the floor) or a steel plate can be used. For this solution a steel plate with a thickness of 25mm, is recommended, having a planarity tolerance: ▱ 0,5 and secured with hex head screws M16 (8.8).

Fig. 7.1 - Robot-base attachment screws and pins



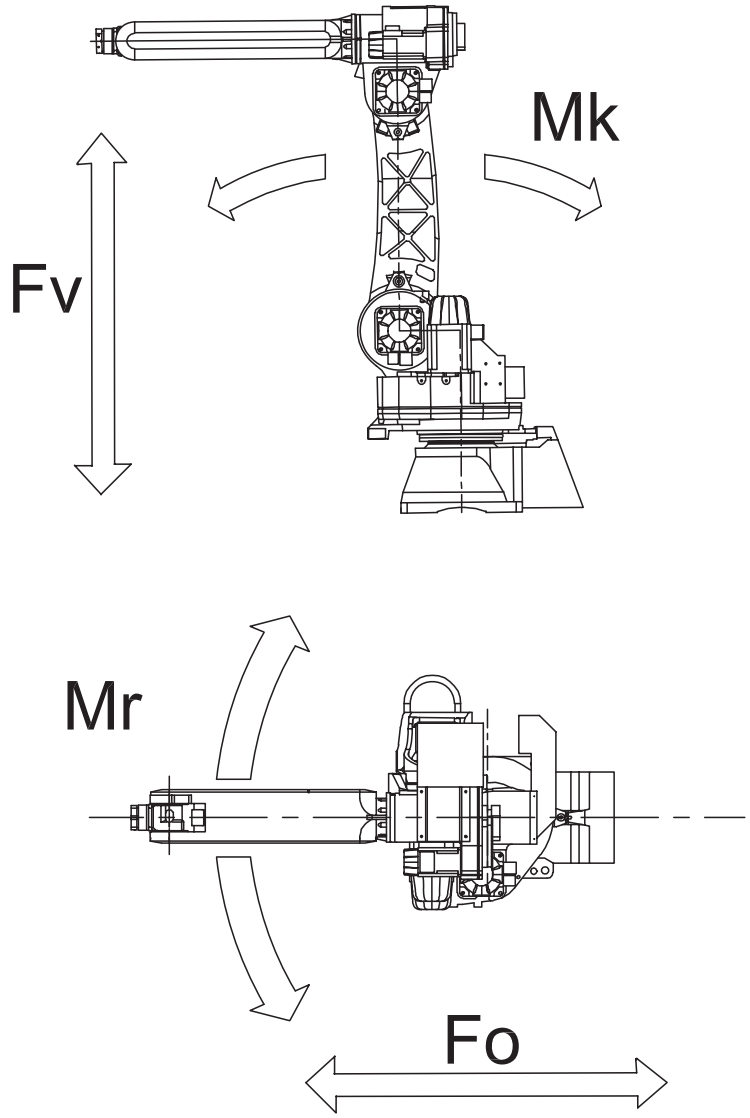
1. Location Ø = 16 mm L = 53 mm (q.ty = 1)
2. Location Ø = 16 mm L = 43mm (q.ty = 1)
3. Socket head cap screw M 6 x 60 (8.8) (q.ty = 1)
4. Socket head cap screwM 6 x 50 (8.8) (q.ty = 1)
5. Partially threaded hex head screw M 16 x 50 (8.8.) (q.ty = 4)
6. Split washer Ø = 16mm (q.ty = 4)
7. Flat washer Ø = 16 mm (q.ty = 4)

Fig. 7.2 - Level adjustment plate



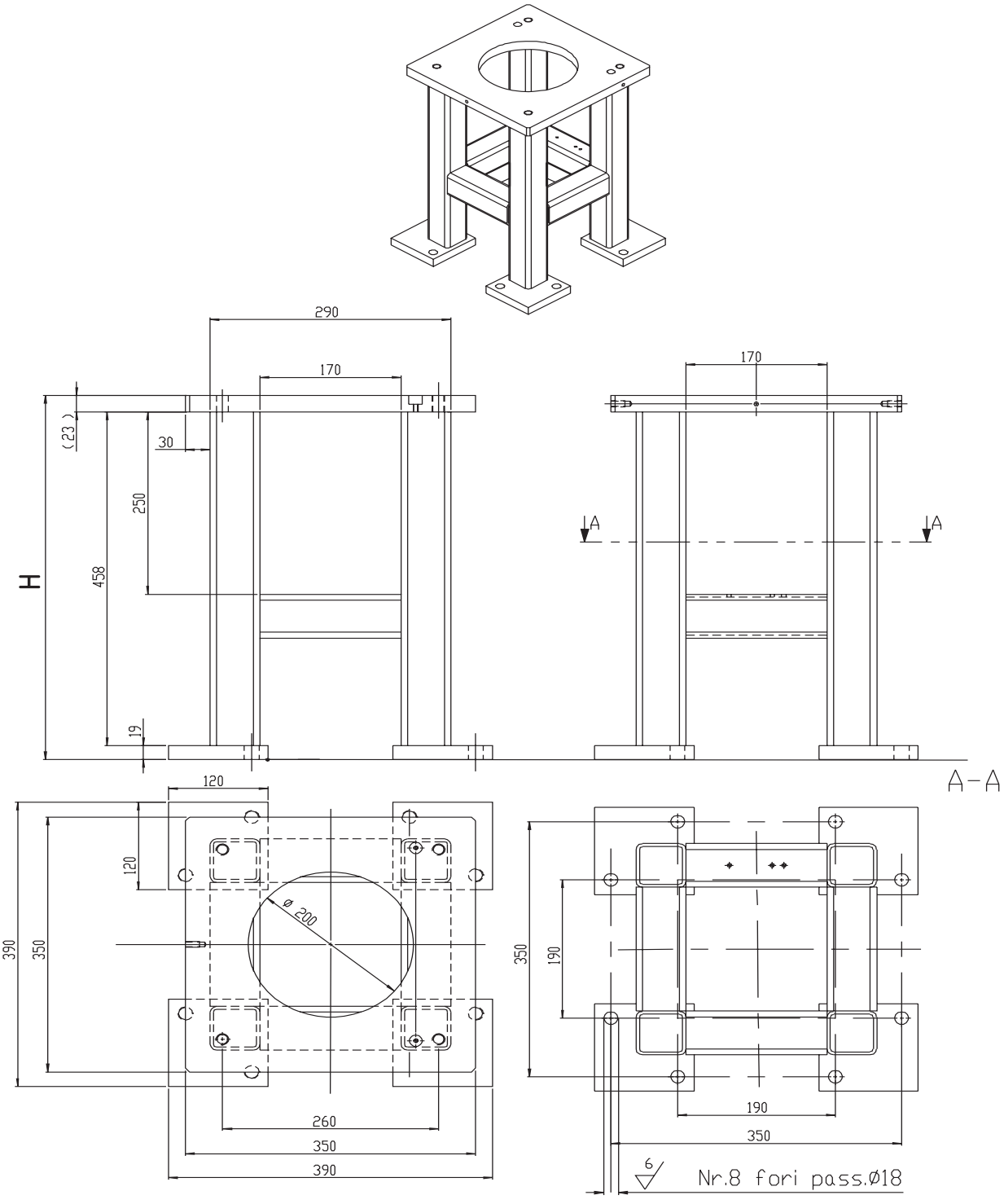
1. Level adjustment plate (qty =1)
2. Plate (qty= 4)
3. Straight edge (qty= 8)
4. Fully threaded hex head screw M16x100-CL 8.8 (qty= 4)
5. Hex nut M16 -8 FE/ZN 12 (qty= 4)

Fig. 7.3 - Stress at ground level generated by robot



SMART SiX				
Robot Movement	**Fv (N)**	**Fo (N)**	**Mr (Nm)**	**Mk (Nm)**
In acceleration	2500	1100	800	2200
In emergency braking	3100	2200	1600	3800

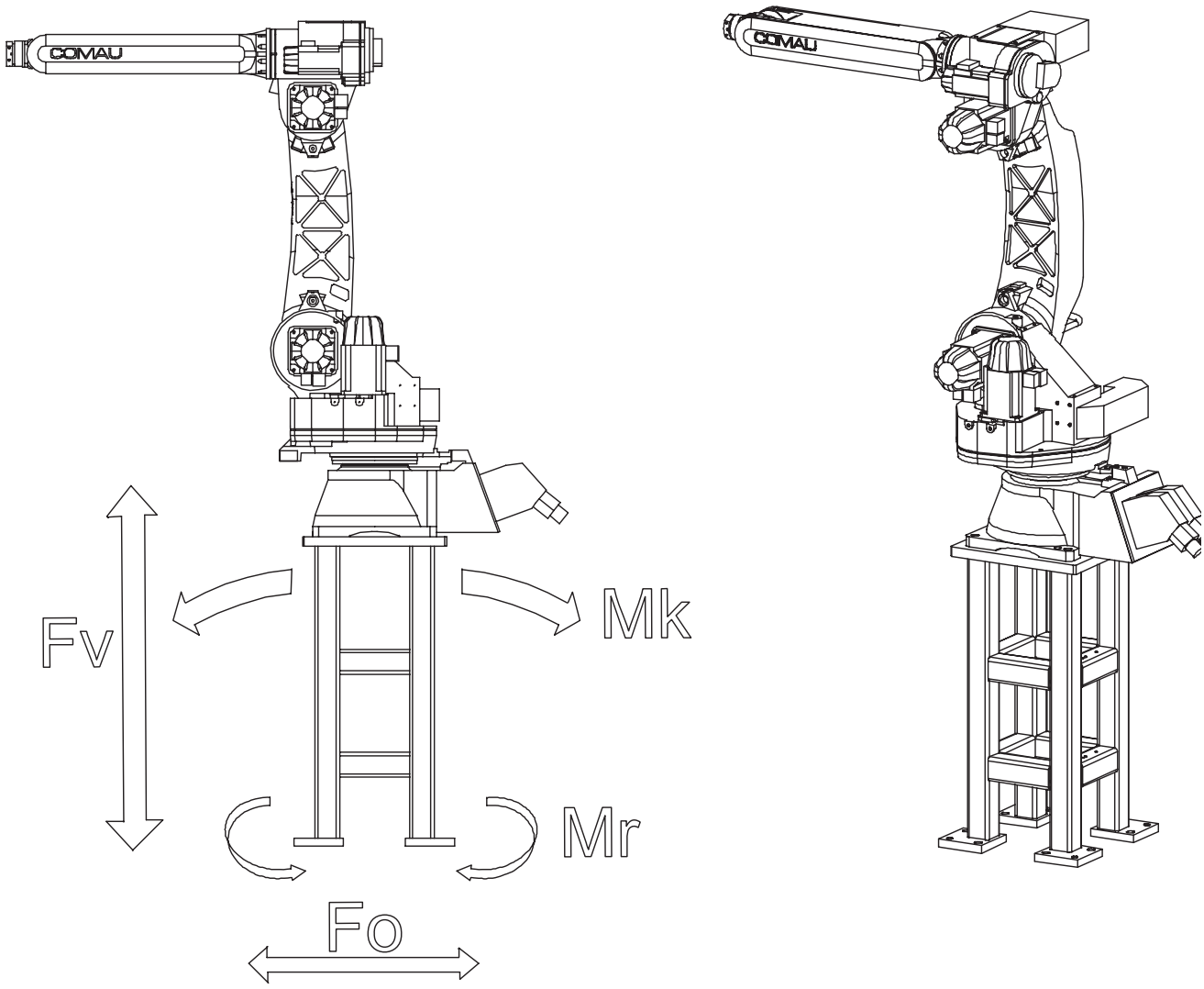
Fig. 7.4 - Raised support with horizontal plane



Height of support: code CR 82221809 H = 500 mm
code CR 82221810 H = 750 mm
code CR 82221811 H = 1000 mm

If the support is secured to a plate, it is recommended to use a steel plate with a thickness of 25mm, planarity tolerance: ⏥ 0,5 and hex head screws M16 (8.8).

Fig. 7.5 - Stress to ground generated by robot secured on a raised support with horizontal plane



SMART SiX				
Robot Movement	**Fv (N)**	**Fo (N)**	**Mr (Nm)**	**Mk (Nm)**
In acceleration	3100	1100	800	3300
In emergency braking	3700	2200	1600	6000

Maximum stress occurs when the robot is installed on a support with maximum height (H=1000 mm).

7.3 Installing the robot on a sloping surface

If the robot is installed on a sloped plane (see Fig. 7.6), besides the indications contained in par. 7.2 Robot installation on horizontal plane on page 7-1, the stroke limitation of axis 1. that can be obtained from the graph in Fig. 7.7 - Limitation of the axis 1 stroke with the robot installed on a sloping surface has to be taken into consideration. For example, with the robot secured to a plane with a 40° inclination, the axis 1 rotation is limited to ± 60°.

If a support is used with a sloped securing plane (see Fig. 7.8 - Raised support with sloped plane), the stress discharged to the ground by the robot is indicated in Fig. 7.9 - Stress to the ground generated by robot secured to a raised support with sloped plane and it is not the same as that generated when a support with a horizontal plane is used.

Fig. 7.6 - Installing the robot on a sloping surface

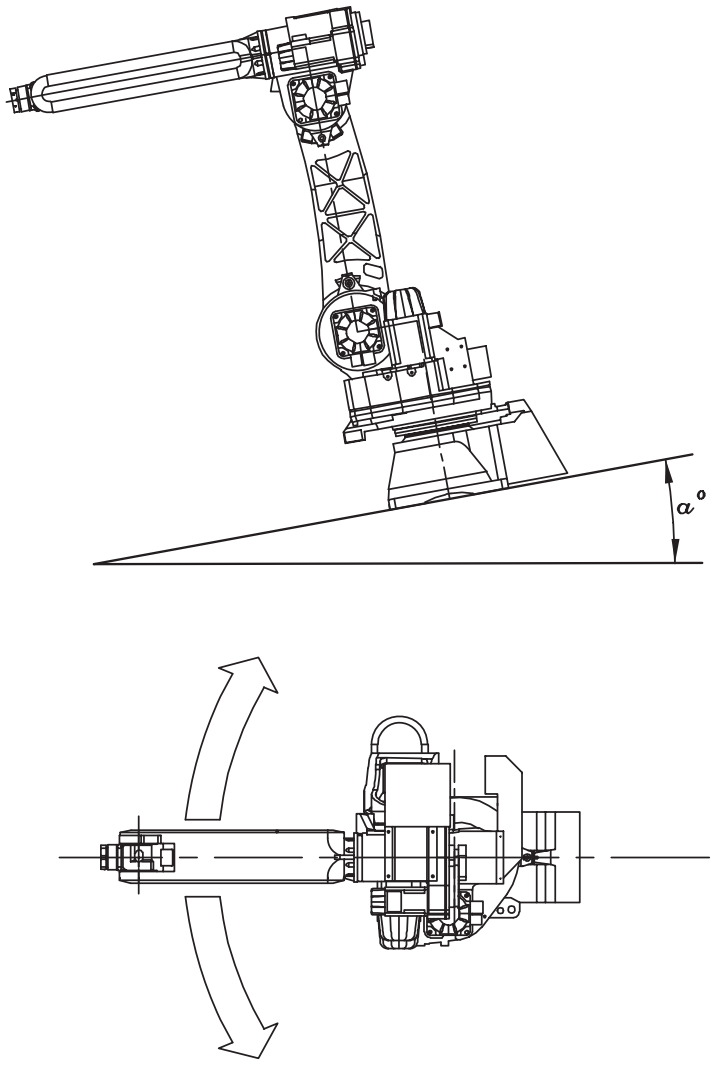
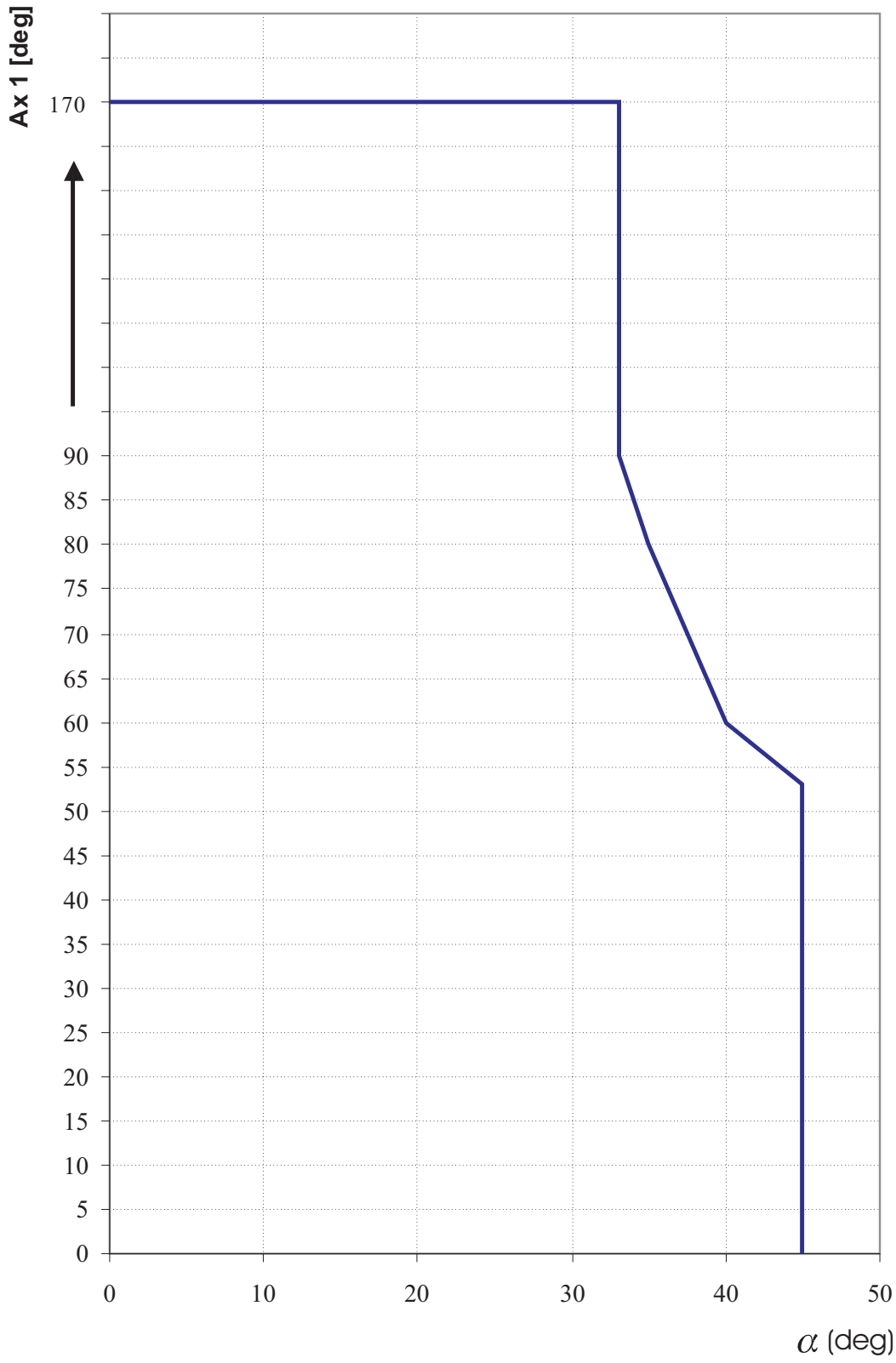
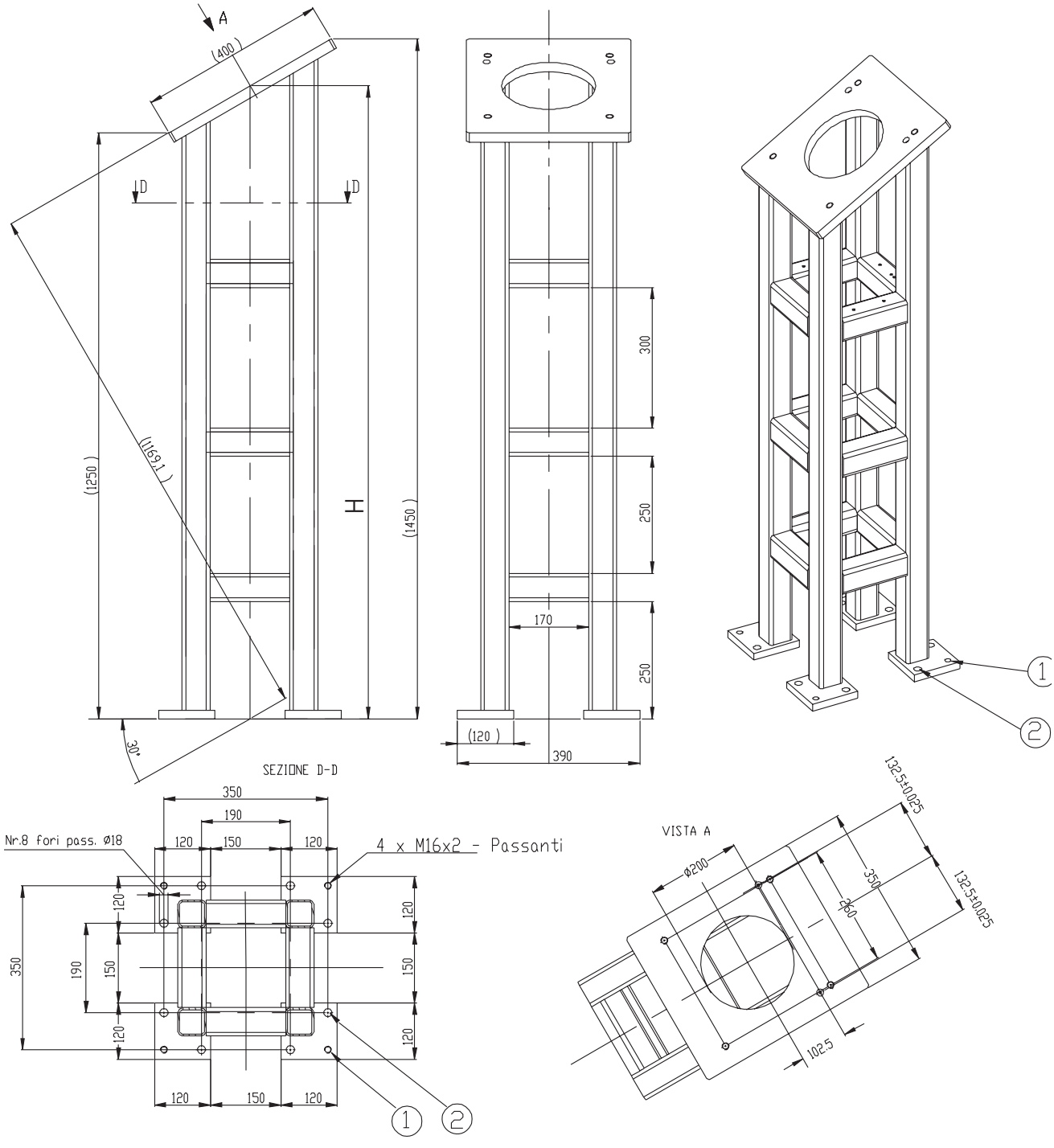


Fig. 7.7 - Limitation of the axis 1 stroke with the robot installed on a sloping surface



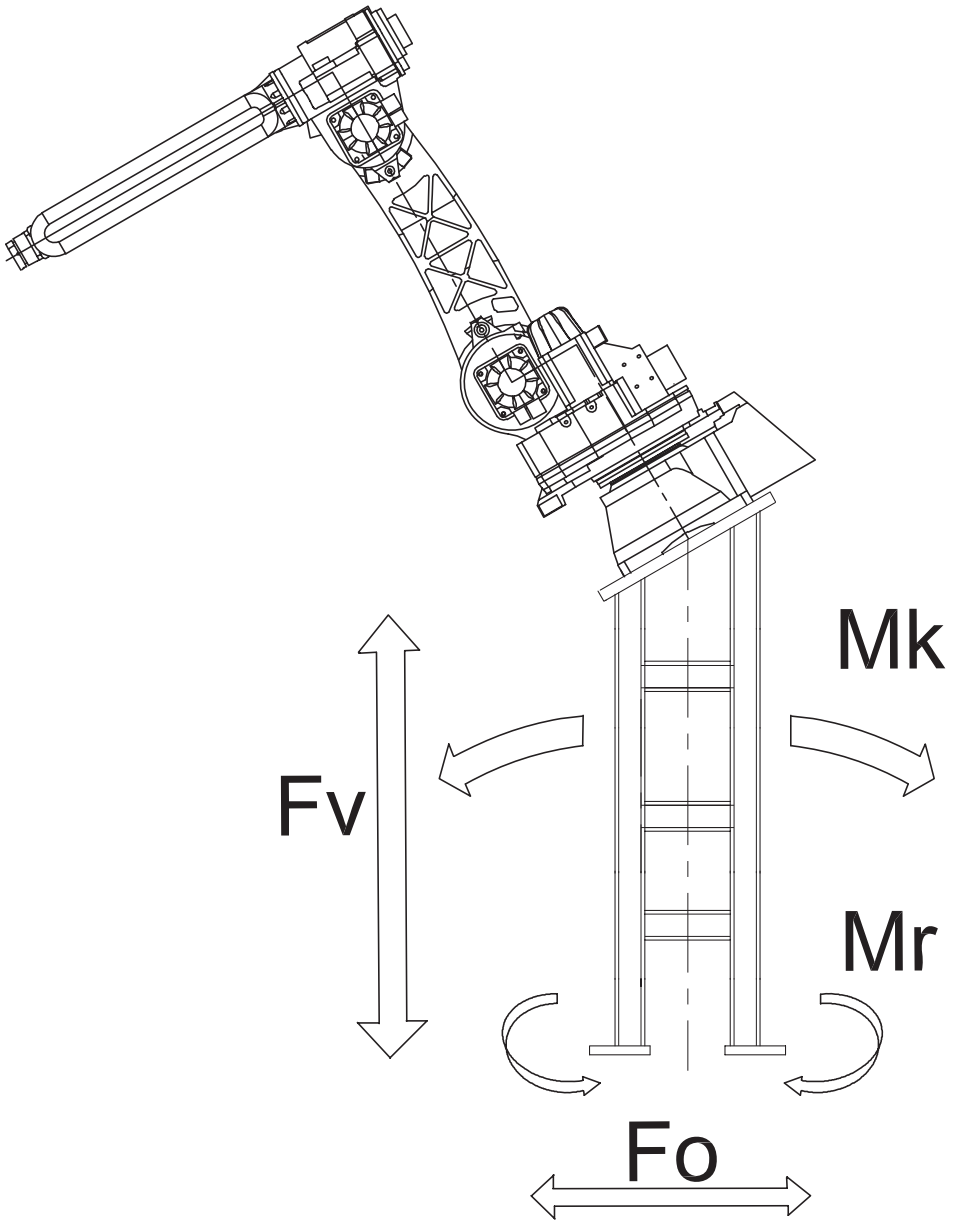
- α = Tilting angle of the robot-base mounting plate
- Ax 1 = Allowed stroke of axis 1

Fig. 7.8 - Raised support with sloped plane



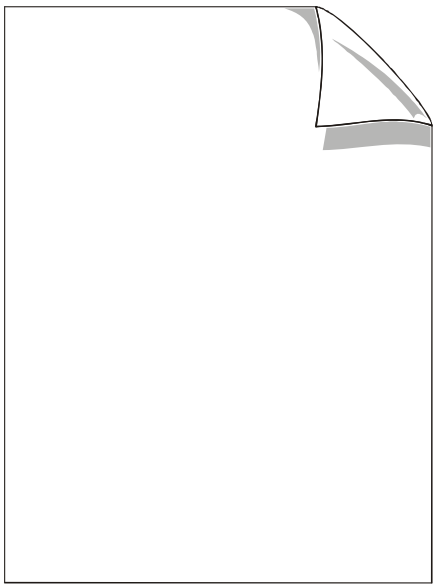
If the support is secured to a plate, it is recommended to use a steel plate with a thickness of 25mm, planarity tolerance: ▱ 0,5 and hex head screws M16 (8.8).

Fig. 7.9 - Stress to the ground generated by robot secured to a raised support with sloped plane



SMART SiX				
Robot Movement	**Fv (N)**	**Fo (N)**	**Mr (Nm)**	**Mk (Nm)**
In acceleration	3300	1100	1000	4000
In emergency braking	4000	2200	2000	7000

Maximum stress occurs when installed on a support of maximum height (H=1350 mm).



8. OPTIONAL EQUIPMENT

8.1 General description

Tab. 8.1 - Applicability of options

Code	Description	Quantity that can be installed
CR82222200	Axis 1 adjustable mechanical hard stop assembly	1
CR82222300	Axis 2 adjustable mechanical hard stop assembly	1
CR82222400	Screws and pins kit for robot mounting	1
CR82222600	Leveling plate unit	1
CR82282100	Manual calibration kit	1
CR81783801	Gauged tool assembly (code 81783801)	1
CR82223000	Wire Welding System Application	1
CR 82221809 CR 82221810 CR 82221811	Support (code CR 82221809 - CR 82221810 - CR 82221811)	1
CR 82221812	Support (code CR 82221812)	1

8.1.1 Axis 1 adjustable mechanical hard stop assembly

8.1.1.1 Description

The axis 1 adjustable mechanical hard stop assembly can be used to limit the stroke of axis 1 in both directions of work with steps of 15°. The assembly consists of two stop pads that are fastened, by means of the screws supplied with the robot, in the seats on the robot base to limit the stroke of axis 1 in both directions; it is possible to use just one of the two stop pads to limit the stroke in one direction only.
The axis 1 adjustable mechanical hard stop assembly satisfies “operator safety” requirements as it can absorb all of the kinetic energy of the axis.

WARNING

Once the stop has been used (impact), the following parts must be replaced:

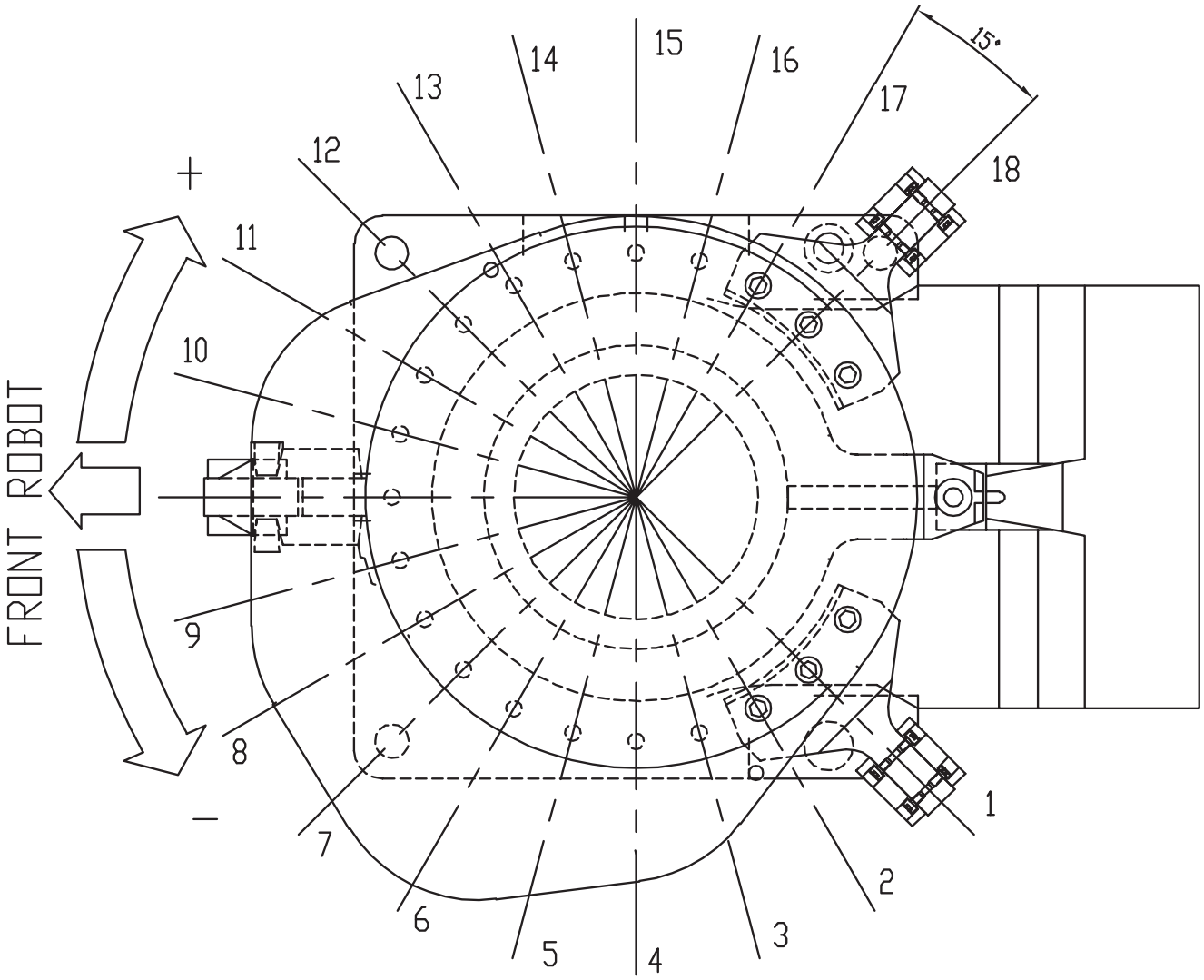
- **mechanical hard stop and fastening screws;**
- **rubber stop blocks and fastening screws.**

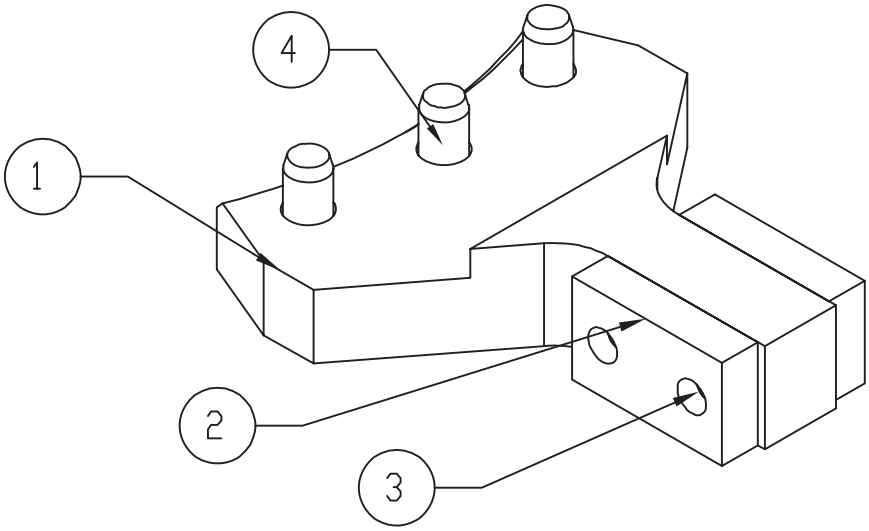
Also the integrity of the robot parts involved is to be checked, for example:

- **the part of the base housing the assembly;**
- **the part of the column housing the stop;**
- **the equipment being used by the robot.**

Failure to replace any damaged parts will undermine correct operation (and thus stopping) in future.

After an impact, check the clearance on axis 1 and correct any slackening of the axis.



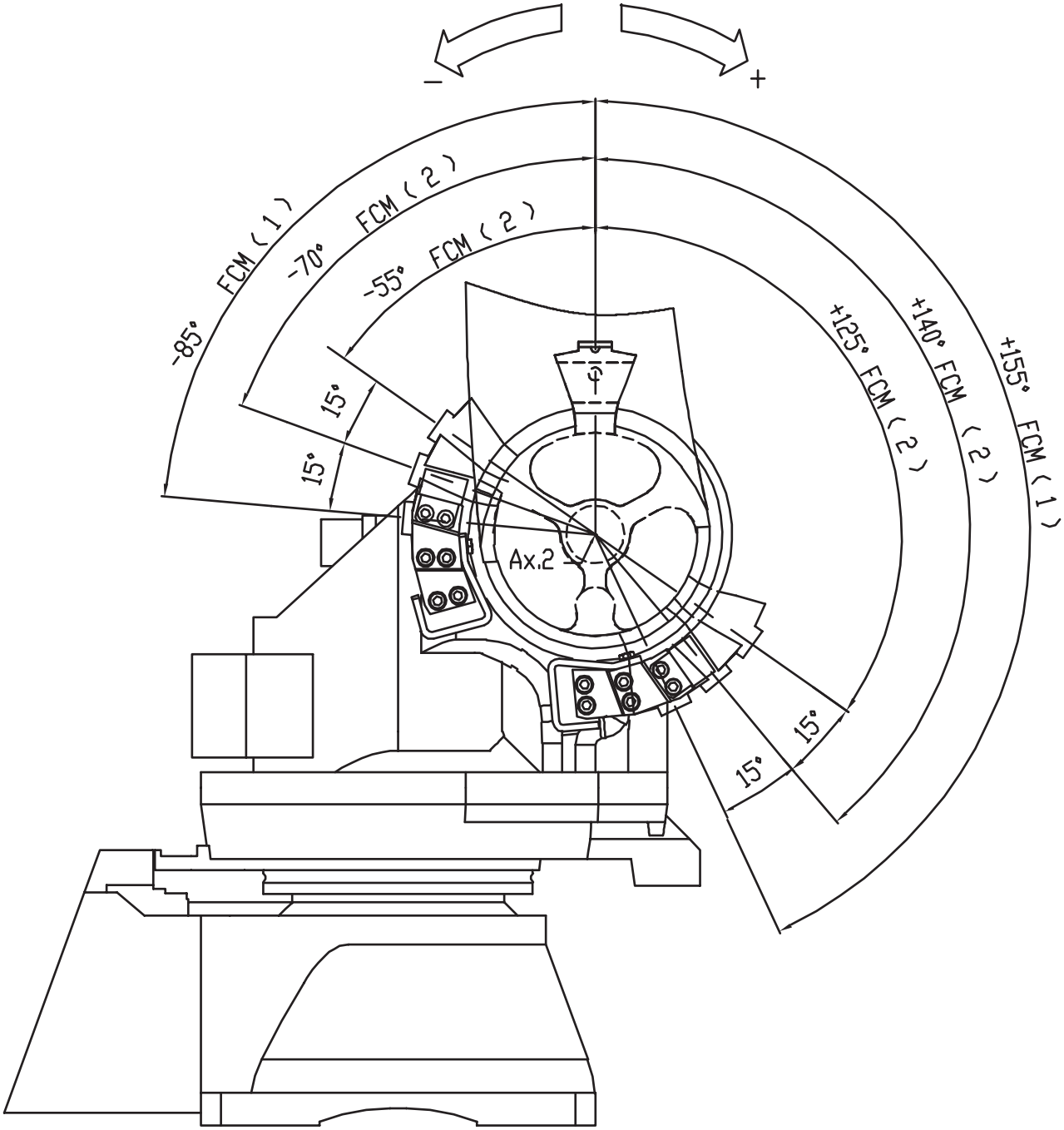


1. Limit switches (q.ty 2)
2. Axis 1 pad (q.ty 4)
3. Socket head cap screw M4x8 cl 8.8(q.ty 8)
4. Socket head cap screw M10x25 cl 12.9 (q.ty 6)

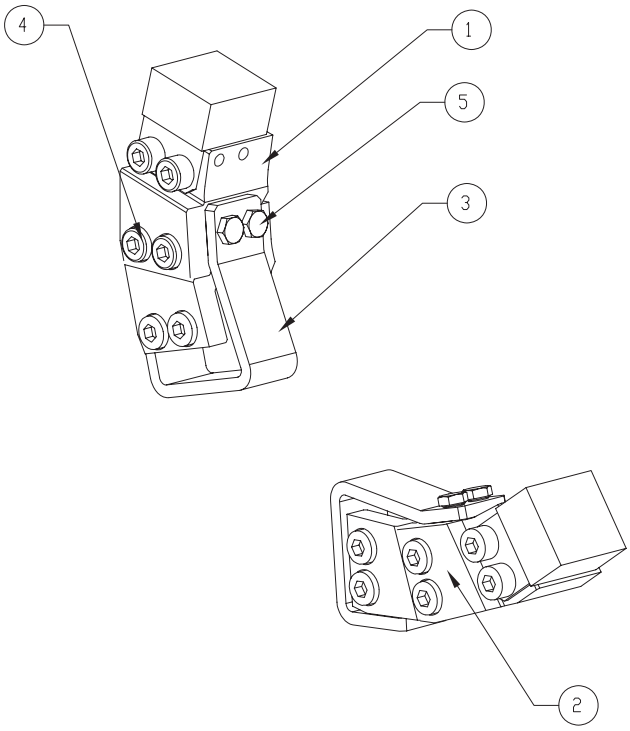
8.1.2 Axis 1 strokes with the adjustable mechanical stop assembly

Pos.	Corsa asse 1 in senso negativo *Axis 1 negative stroke*		Corsa asse 1 in senso positivo *Axis 1 positive stroke*	
	da / *from* [°]	a / *to* [°]	da / *from* [°]	a / *to* [°]
1	0	-35	0	+170
2	0	-50	0	+170
3	0	-65	0	+170
4	0	-80	0	+170
5	0	-95	0	+170
6	0	-110	0	+170
7	0	-125	0	+170
8	0	-140	0	+170
9	0	-155	0	+170
	0	-170	0	+170
10	0	-170	0	+155
11	0	-170	0	+140
12	0	-170	0	+125
13	0	-170	0	+110
14	0	-170	0	+95
15	0	-170	0	+80
16	0	-170	0	+65
17	0	-170	0	+50
18	0	-170	0	+35

8.1.3 Axis 2 adjustable mechanical hard stop assembly



1. Stroke limitation with standard limit switches
2. Stroke limitation with optional limit switches



1. Rear block
2. Front block
3. Bracket
4. Socket head cap screw M 8x16 (cl 12,9) (qty 8)
5. Socket head cap screw M 6x12 (cl 8,8)interamente filettata(qty 2)

8.1.3.1 Description

The axis 2 adjustable mechanical hard stop assembly can be used to limit the stroke of axis 2 in both directions of work with steps of 15°.
The assembly consists of two sets of 2 blocks that are fastened to the structure of the column so that they rest against the rebound pads on the robot.

The positive stroke can be limited to +125° or +140° (instead of the standard +155° stroke) and the negative stroke can be limited to -55° or -70° (instead of the standard -85° stroke).
The axis 2 adjustable mechanical hard stop assembly satisfies “operator safety” requirements as it can absorb all of the kinetic energy of the axis.

The limitation of the operating area obtained by installing the stop assembly is shown in the Operating Area Limitation diagrams in Chap. Operating Areas and Robot Overall Dimensions.

WARNING
Once the stop has been used (impact), the following parts must be checked for correct operation:

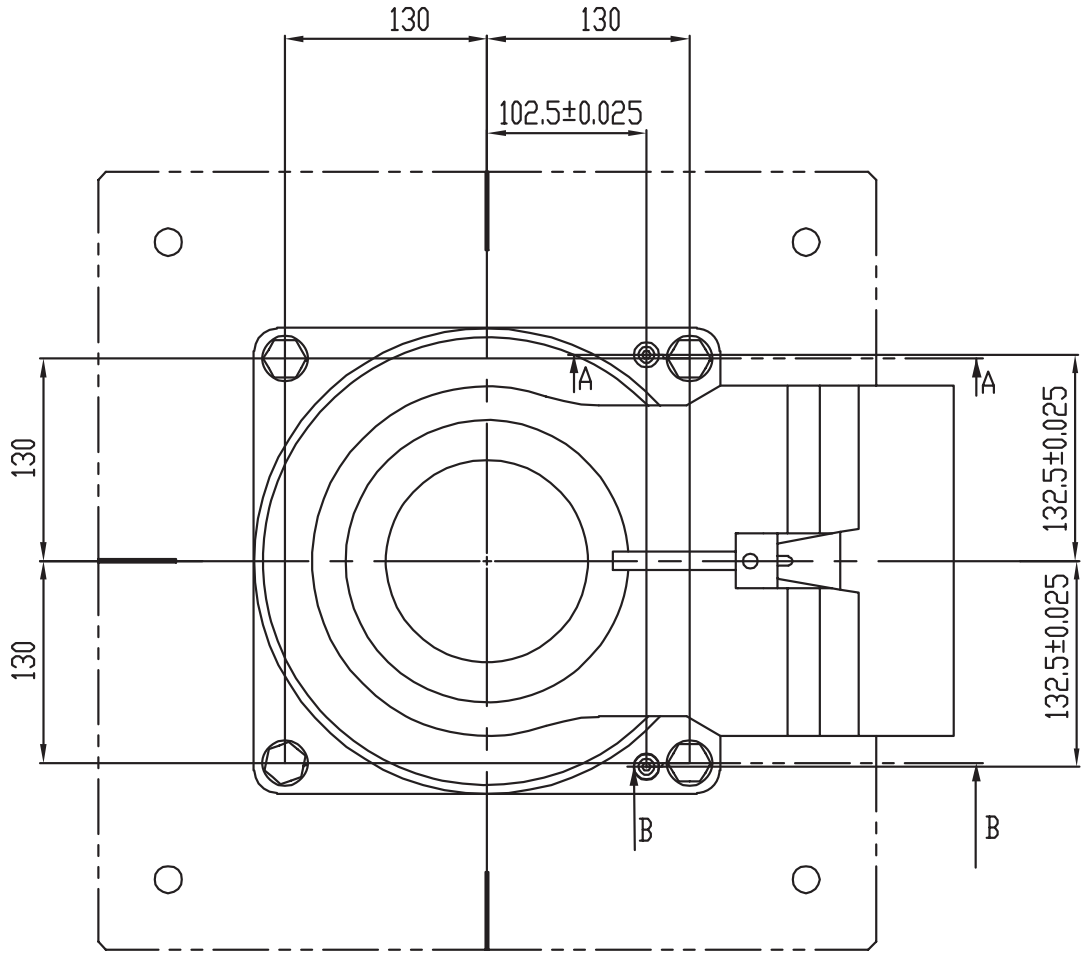
– **mechanical stop**;

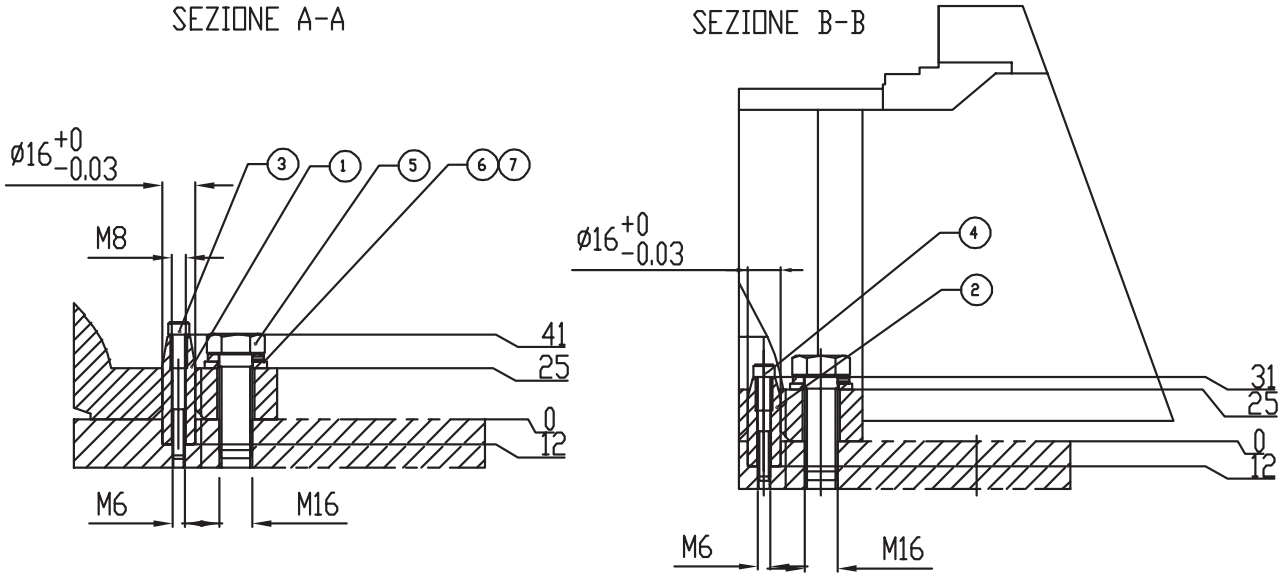
– **rubber stop blocks and fastening screws.**

– **the equipment being moved by the robot.**

Failure to replace any damaged parts will undermine correct operation (and thus stopping) in future.

8.1.4 Screws and pins kit for robot mounting



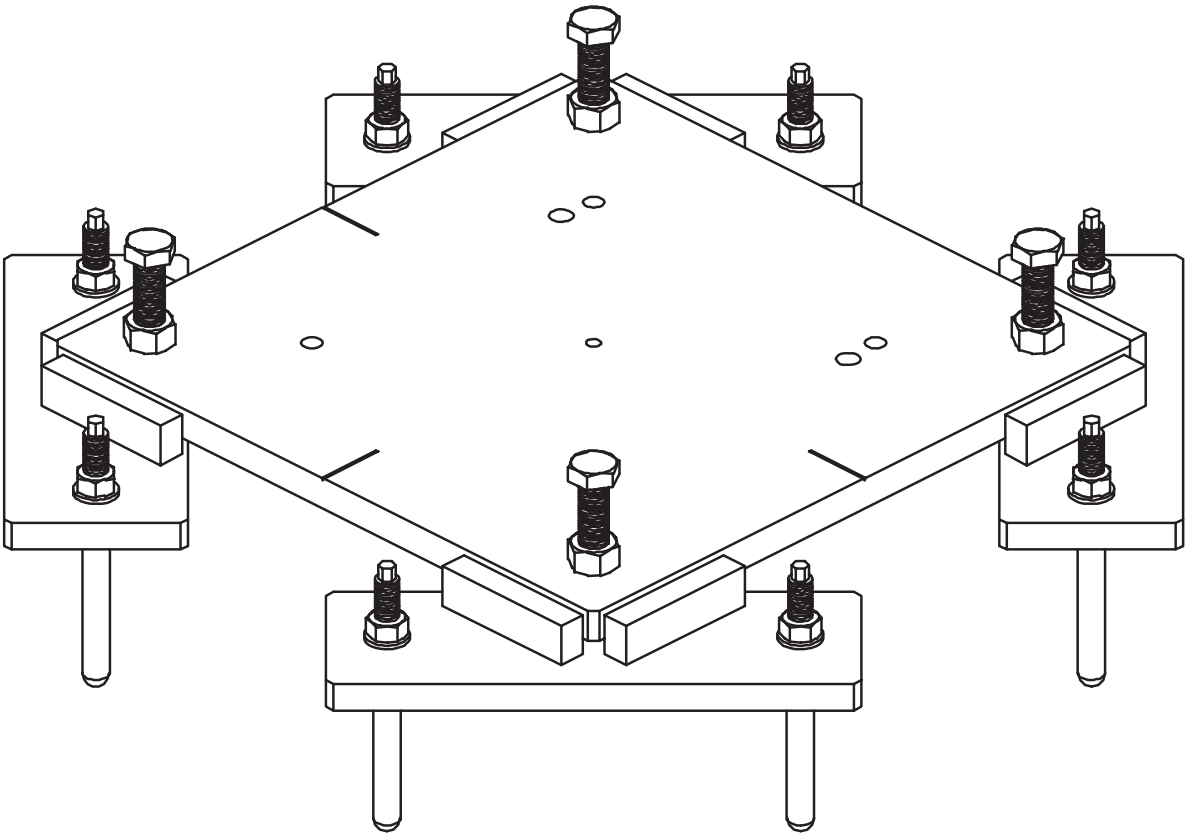


1. Location Ø = 16 mm L = 53 mm (q.ty = 1)
2. Location Ø = 16 mm L = 43mm (q.ty = 1)
3. Socket head cap screw M 6 x 60 (8.8) (q.ty = 1)
4. Socket head cap screw M 6 x 50 (8.8) (q.ty = 1)
5. Partially threaded hex head screw M 16 x 50 (8.8.) (q.ty = 4)
6. Split spring washer Ø = 16mm (q.ty = 4)
7. Flat washer Ø = 16 mm (q.ty = 4)

8.1.4.1 Description

For the robot assembly an optional group can be used consisting of two pins and four M16 screws needed to attach the robot-base to a steel plate.
The preparation and attachment of the plate to the floor or to the supporting structure are to be carried out by the robot installer.

8.1.5 Leveling plate unit



8.1.5.1 Description

The robot leveling plate assembly is used to ensure that the robot is anchored correctly to the floor. This assembly satisfies the following requirements:

– it ensures good mounting plate levelness, to avoid any incorrect stresses on the structure of the robot base.

– a perfectly aligned robot assembly that facilitate "off-line programming" applications.

The assembly consists of:

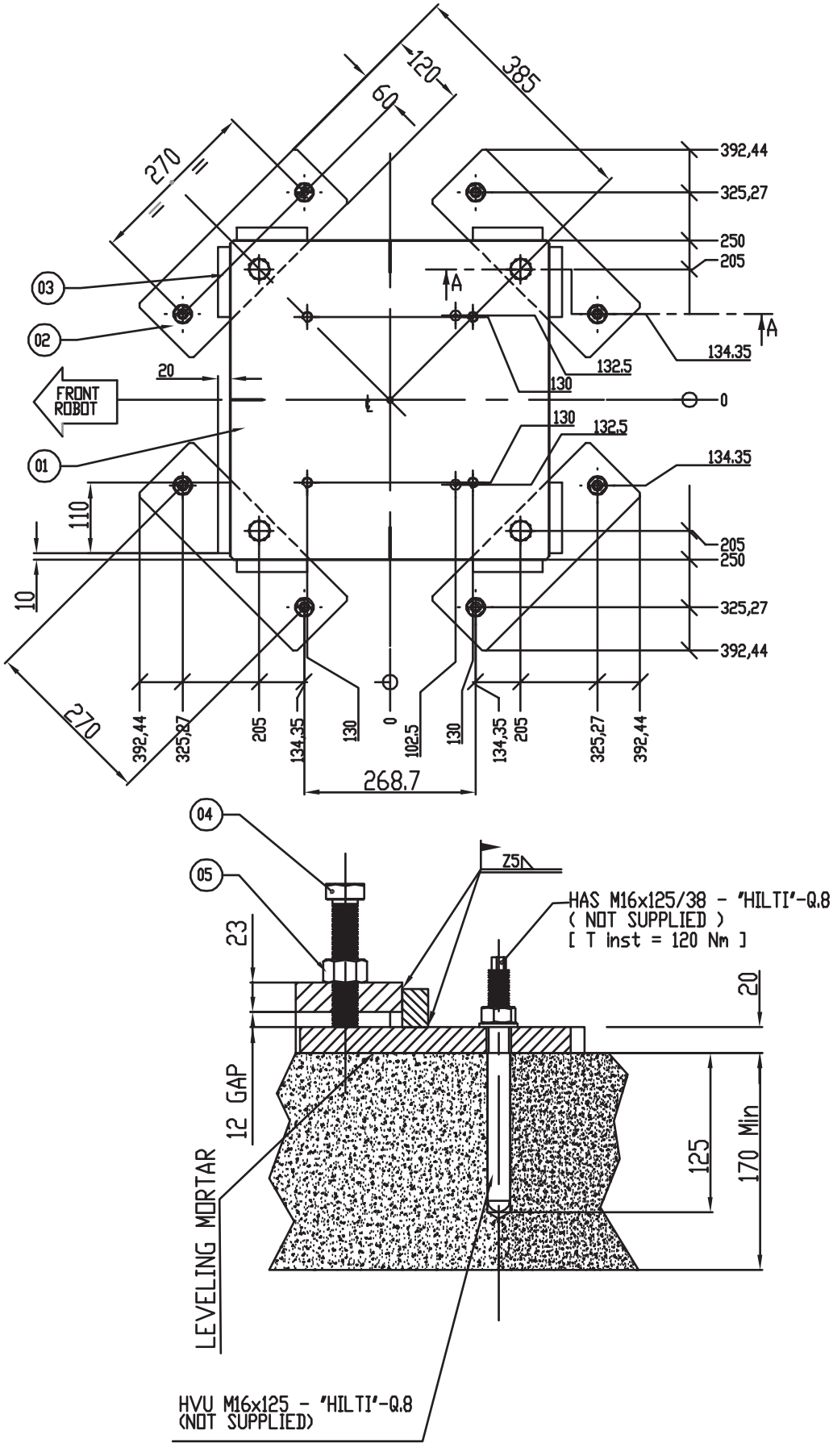
– four steel plates that are anchored to the floor by means of chemical bolts (for a total of 8 anchor bolts, which are not supplied).

– a leveling plate that is welded to the plates described above after using the specific adjustment screws to obtain optimal robot leveling.

Legend Fig. 8.1 - Leveling plate unitf

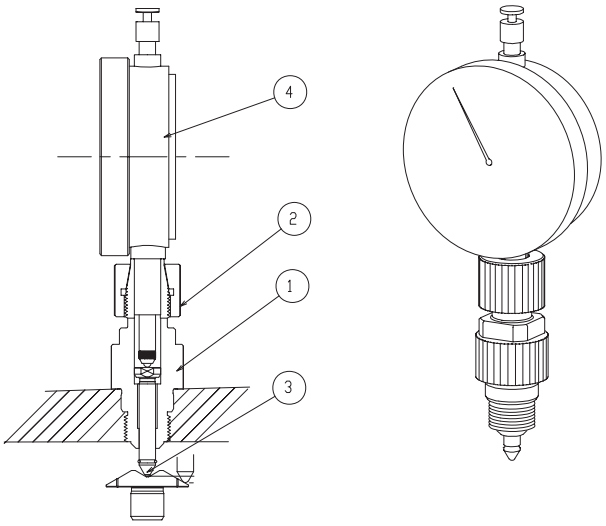
1. Leveling plate (q.ty =1)
2. Plate (q.ty 4)
3. Straight edge (q.ty = 8)
4. Fully threaded hex head cap screw M16x100-CL 8.8 (q.ty = 4)
5. Hex nut (M16 -8 FE/ZN 12 (q.ty = 4)

Fig. 8.1 - Leveling plate unitf



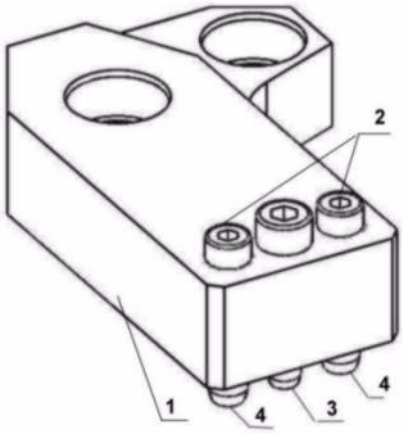
8.1.6 Manual calibration kit

Calibration tool for axes 1-2-3



1. Dial gauge holder
2. Tapered ring nut
3. Probe
4. Dial gauge

Support fixture for axes 4-5-6



1. Calibration block
2. Socket head cap screw
   M4x10 - 8.8 - ISO 4762 (qty 2)
3. Socket head cap screw
   M5x25 - 8.8 - ISO 4762 (qty 1)
4. Parallel pins
   ISO 8734 - 6x20 - B - St

8.1.6.1 Description

The manual calibration kit consists of the following parts:

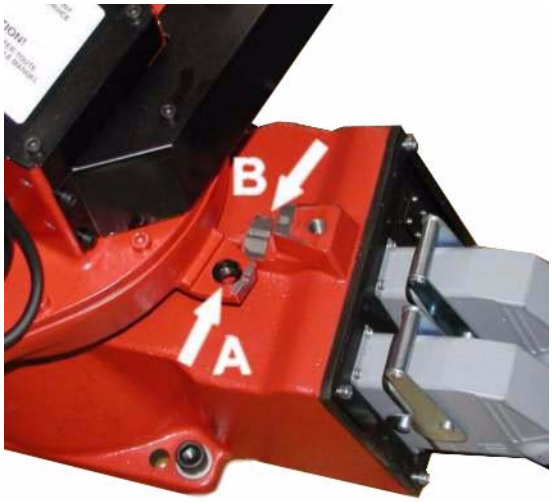
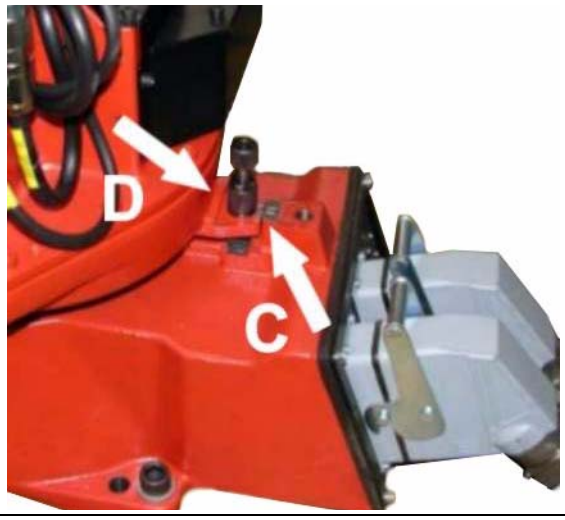
– a dial gauge holder fixture to screw to the housings on axes 1-2-3.

– a support for the dial gauge holder fixture to be fastened with screws and pins to the housings provided for axes 4-5-6.

– a centesimal dial gauge to carry out the correct calibration of each robot axis in manual mode

The kit is used to find the calibration position of the axis that corresponds to the minimum reading position read on the dial gauge with reference to the foreseen indexes in each robot axis.

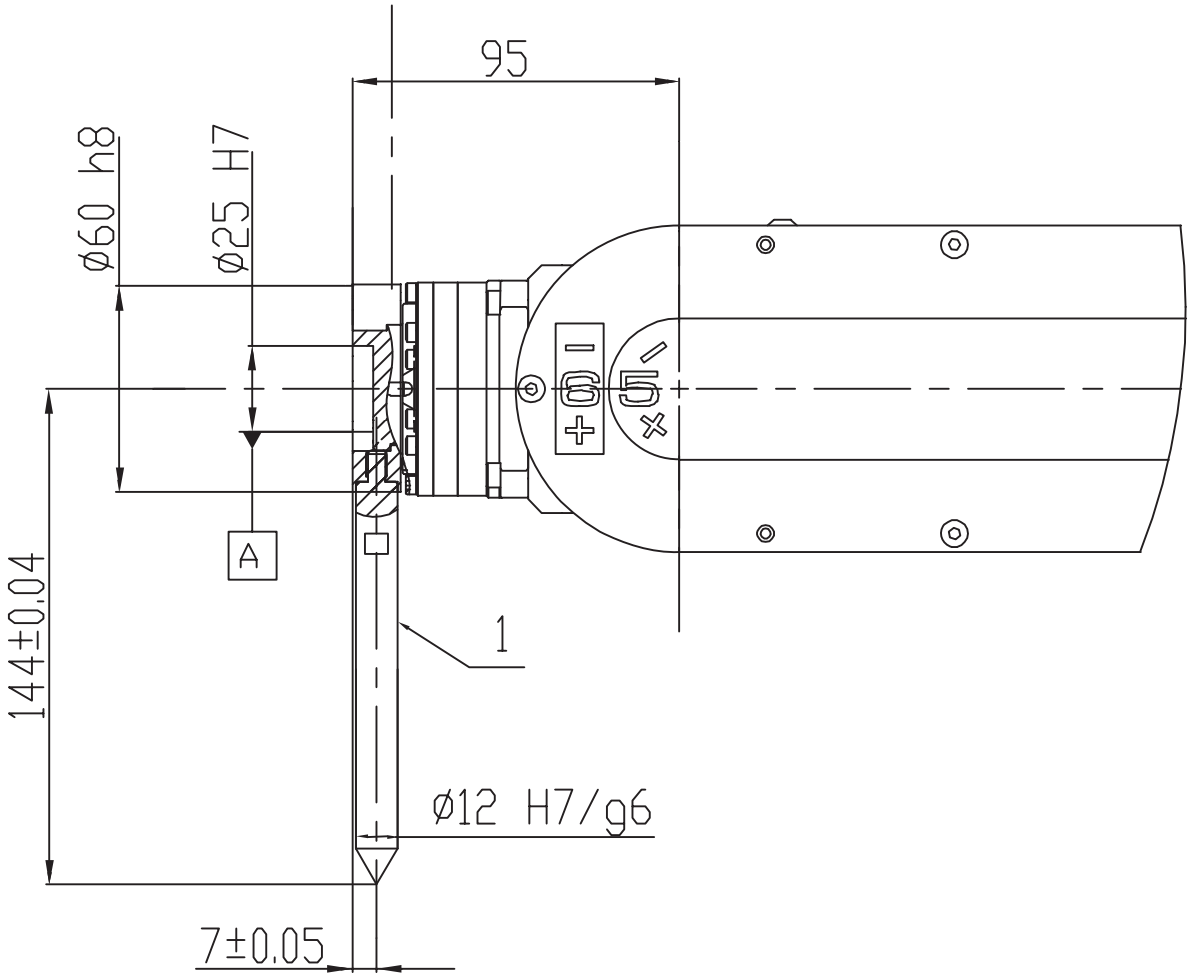
Tab. 8.2 - Example of axis 1 calibration

Removal of the protections from the reference index and from the housing for the dial gauge holder fixture	
Visual alignment of the reference planes for calibration and assembly of the dial gauge holder fixture	
Assembly of dial gauge holder fixture and search for calibration point	

Tab. 8.3 - Example of the kit used to calibrate axes 4 - 5- 6

Assembly of support and dial gauge holder fixture and search for axis 4 calibration point	
Assembly of support and dial gauge holder fixture and search for axis 5 calibration point	
Assembly of support and dial gauge holder fixture and search for axis 6 calibration point	

8.1.7 Gauged tool assembly (code 81783801)

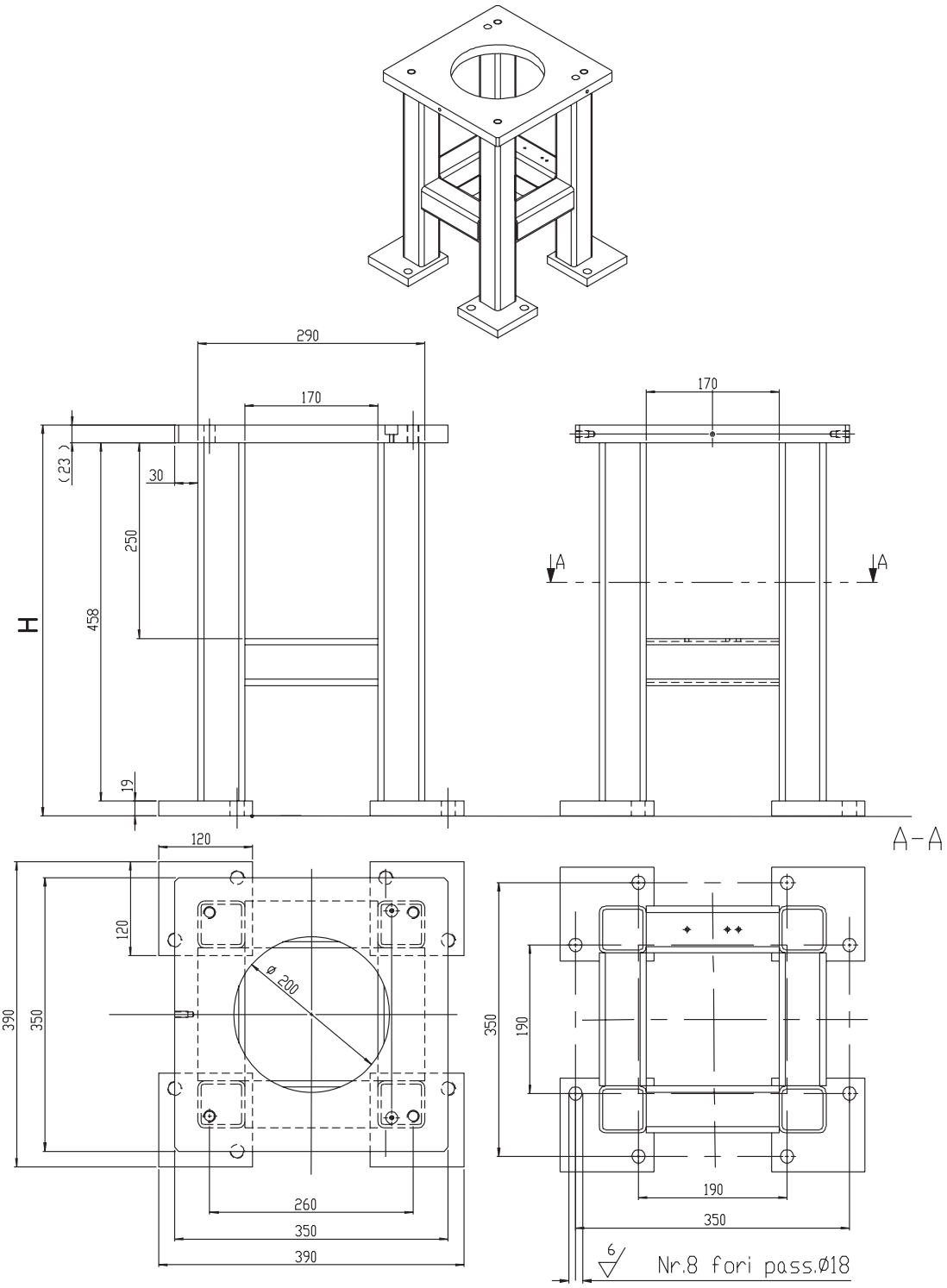


1. Gauged tool (code 81783801)

8.1.7.1 Description

The gauged tool assembly is used to calculate the **TCP** (Tool Center Point) in relation to the robot flange.
The assembly consists of a cylindrical test rod of a length that is defined so that the end is at an exact position in relation to the center of the wrist.
The prod is screwed directly onto the axis 6 output flange in a radial position in relation to the latter and there is no need to disassemble any tools that are installed on the flange.

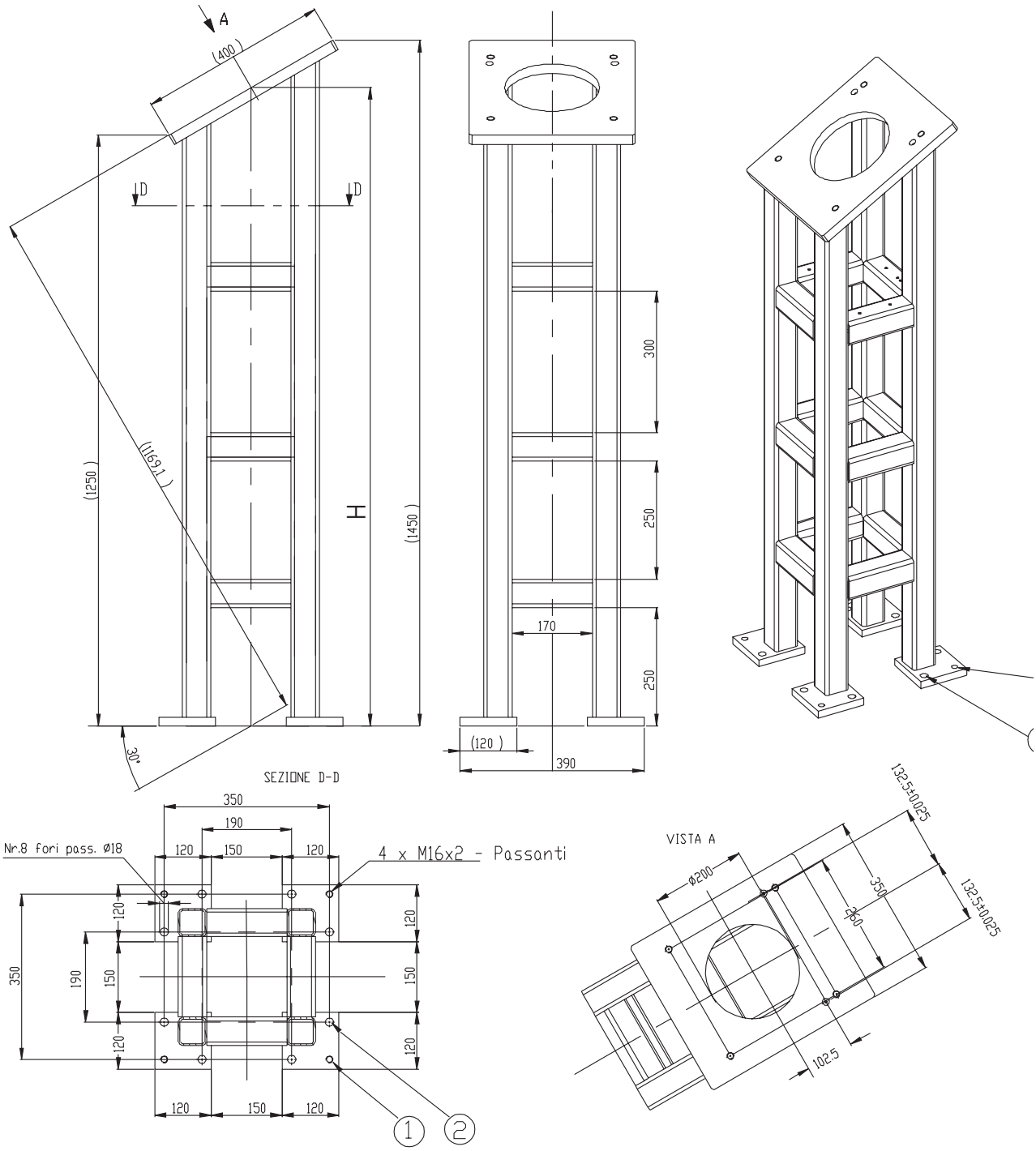
8.1.8 Support (code CR 82221809 - CR 82221810 - CR 82221811)

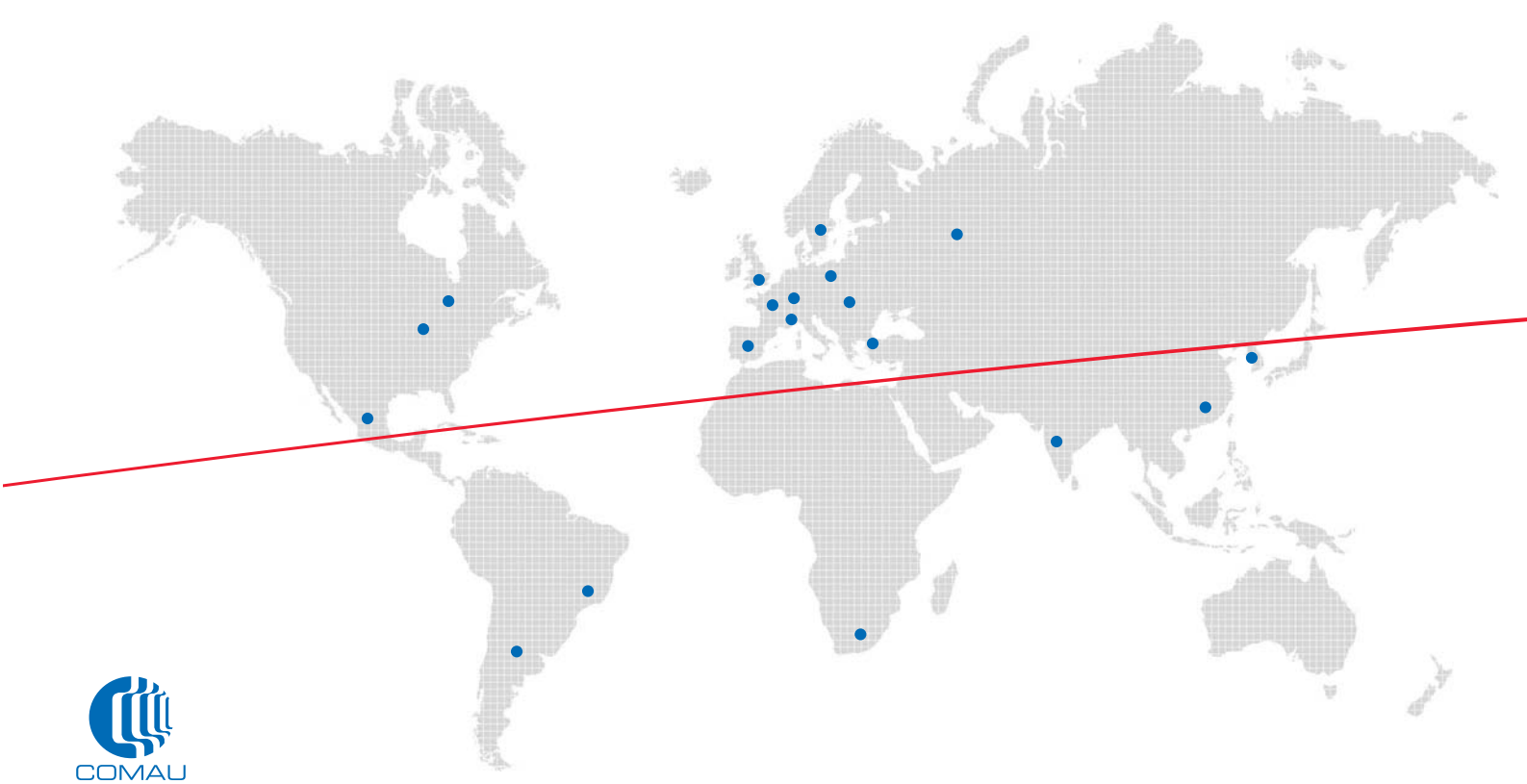


Support height :

– code CR 82221809 H = 500 mm
– code CR 82221810 H = 750 mm
– code CR 82221811 H = 1000 mm

8.1.9 Support (code CR 82221812)





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