SMART NM in line
SMART NM off set
SMART NM 16 3.1
SMART NM Foundry
SMART NM 45 2.0 Wash

Technical Specifications
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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 following robots:

- SMART NM in line
- SMART NM off set
- SMART NM foundry
- SMART NM wash
- SMART NM 16 3.1

The complete set of manuals that document the robot system and control consists of:

<table>
<thead>
<tr>
<th>Comau</th>
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<td>SMART NM</td>
<td>– Transport and installation</td>
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</tr>
<tr>
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<td>SMART NM 16 3.1</td>
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These manuals are to be integrated with the following documents:

<table>
<thead>
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<th>Comau</th>
<th>C4G Control Unit</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>– Transport and installation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Guide to integration, safeties, I/O and communications</td>
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<td>– Electrical diagram</td>
</tr>
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</table>

- EZ PDL2 Easy programming environment
- PDL2 Programming Language Manual
- VP2 Visual PDL2
- 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 included in the spare parts list.

– 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 eyebolts 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.
General Safety Precautions

- 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 (emergency stop, gates safety 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.

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 SMART NM Robot

SMART NM is the COMAU family of robots with medium payload, consisting of machines for applications that require "point to point" or "trajectory" control programming.

The most common applications are:
  – handling
  – welding
  – assembly
  – adhesive, sealant, protection applications
  – machining for chip removal (E.g.: trimming, grinding)

The versions available in the SMART NM robot family are listed below:

<table>
<thead>
<tr>
<th>Model</th>
<th>Version</th>
<th>Payload (kg)</th>
<th>Reach (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMART NM 25-2.2 In -line</td>
<td>25-22</td>
<td>25</td>
<td>2200</td>
</tr>
<tr>
<td>SMART NM 25-2.2 Foundry</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SMART NM 45-2.0 In -line</td>
<td>45-2.0</td>
<td>45</td>
<td>2000</td>
</tr>
<tr>
<td>SMART NM 45-2.0 Foundry</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SMART NM 45-2.0 Wash</td>
<td>25-22</td>
<td>25</td>
<td>2200</td>
</tr>
<tr>
<td>SMART NM 45-2.0 Off-set</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SMART NM 16 3.1</td>
<td>16-3.1</td>
<td>16</td>
<td>3100</td>
</tr>
</tbody>
</table>

The Foundry versions are appropriate for applications in environments with high temperatures, in fact they guarantee IP 67 protection class on wrist and motors.
Fig. 2.1 - SMART NM 25-2.2 In-line
SMART NM 25-2.2 Foundry

Fig. 2.2 - SMART NM 45-2.0 In-line
SMART NM 45-2.0 Foundry
Fig. 2.3 - SMART NM 45-2.0 Wash

Fig. 2.4 - SMART NM 25-2.2 Off-set
SMART NM 25-2.2 Foundry
Fig. 2.5 - SMART NM 45-2.0 Off-set
SMART NM 45-2.0 Foundry

Fig. 2.6 - SMART NM 16 3.1
The loads indicated (at wrist and additional) applied to the robot 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 terms of 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.

The robot requires 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 substituted 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.

The fixed base is a base fastened to the ground by 4 M16x60 screws and with two special Ø 30 mm pins that ensure a precise location in relation to the fastening plate. A column carrying the axis 2 geared motor rotates on the fixed base around the vertical rotation axis (axis 1).

An arm connects axis 2 to the forearm. The forearm includes the geared motors of axes 3-4 and also supports the motors of axes 4-5-6.

At the end of the forearm there is the wrist that interfaces with the axis 5 driving shaft, and supports the axis 6 reduction unit.

In version NM 16 3.1 the forearm is elongated by a spacer and the wrist is mounted at its front end to handle axes 5-6.

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

For axis 1 there is a specific option to customise the work area according to the application required, allowing the reduction of the axis 1 stroke.
Tab. 2.2 - Axes limit switch availability

<table>
<thead>
<tr>
<th>Robot Model</th>
<th>Standard</th>
<th>On request</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Software limit stop</td>
<td>Movable mechanical hard stop</td>
</tr>
<tr>
<td>SMART NM</td>
<td>Mechanical hard stop</td>
<td></td>
</tr>
<tr>
<td>SMART NM Off Set</td>
<td>Axes 1-2-3-4-5-6</td>
<td>Axes 1-2-3-4-5</td>
</tr>
<tr>
<td>SMART NM 16 3.1</td>
<td></td>
<td>Axis 1</td>
</tr>
</tbody>
</table>

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

All the reduction units are lubricated with oil, except reduction unit axis 5 in the version SMART NM 16 3.1, to guarantee better efficiency; the lubricant only has to be replaced every 15,000 h, equivalent to approx. 3 years operating on 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 axes and 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 a 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 that is the same for all axes and all models. 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 cycles that are particularly demanding in terms of precision must be executed.

– calibration on location notches: this enables rapid but improper calibration with less precision, and it may not reset the robot movements with the precision that is required by the specific application. Calibration by notches consists in 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.
3. TECHNICAL CHARACTERISTICS

3.1 Overview

This chapter contains views and characteristics of the available SMART NM robots.

- Fig. 3.1 - SMART NM 25-2.2 In-line - SMART NM 25-2.2 Foundry overall view
- Fig. 3.2 - SMART NM 45-2.0 In-line - SMART NM 45-2.0 Foundry overall view
- Fig. 3.3 - SMART NM 25-2.2 Off-set - SMART NM 25-2.2 Foundry general view
- Fig. 3.4 - SMART NM 16-3.1 general view
- Fig. 3.5 - SMART NM 45-2.0 In-line Wash general view

- Tab. 3.1 - SMART NM In line Characteristics and performance
- Tab. 3.2 - SMART NM off-set Characteristics and performance
- Tab. 3.3 - SMART NM 16-3.1 Characteristics and performance
- Tab. 3.4 - SMART NM 45-2.0 In-line Wash Characteristics and performance

The working volume and the overall dimensions of all the robots available are contained in Chap. Operating Areas and Robot Overall Dimensions.
Fig. 3.1 - SMART NM 25-2.2 In-line
SMART NM 25-2.2 Foundry overall view
Fig. 3.2 - SMART NM 45-2.0 In-line  
SMART NM 45-2.0 Foundry overall view
Fig. 3.3 - SMART NM 25-2.2 Off-set
SMART NM 25-2.2 Foundry general view
Fig. 3.4 - SMART NM 16 3.1 general view
Fig. 3.5 - SMART NM 45-2.0 In-line Wash general view
### Tab. 3.1 - SMART NM In line Characteristics and performance

<table>
<thead>
<tr>
<th>VERSION</th>
<th>NM 25-2.2 (*)</th>
<th>NM 45-2.0 (*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure / n° axes</td>
<td>Anthropomorphous / 6 axis</td>
<td>Anthropomorphous / 6 axis</td>
</tr>
<tr>
<td>Load at wrist</td>
<td>25kg 55.11lb (1)</td>
<td>45kg 99.20 lb(1)</td>
</tr>
<tr>
<td>Additional load on forearm</td>
<td>40kg 88.18 lb(2)</td>
<td>40kg 88.18 lb(2)</td>
</tr>
<tr>
<td>Torque axis 4</td>
<td>176,58Nm</td>
<td>176,58Nm</td>
</tr>
<tr>
<td>Torque axis 5</td>
<td>176,58Nm</td>
<td>176,58Nm</td>
</tr>
<tr>
<td>Torque axis 6</td>
<td>117,72Nm</td>
<td>117,72Nm</td>
</tr>
</tbody>
</table>

**Stroke / (Speed)**

<table>
<thead>
<tr>
<th>Axis 1</th>
<th>+/-180°(160°/s)</th>
<th>+/-180°(160°/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axis 2</td>
<td>+130°/-53°(150°/s)</td>
<td>+130°/-53°(150°/s)</td>
</tr>
<tr>
<td>Axis 3</td>
<td>+110°/-170°(160°/s)</td>
<td>+110°/-170°(160°/s)</td>
</tr>
<tr>
<td>Axis 4</td>
<td>+/- 2700° (250°/s)</td>
<td>+/- 2700° (250°/s)</td>
</tr>
<tr>
<td>Axis 5</td>
<td>+/-123° (250°/s)</td>
<td>+/-123° (250°/s)</td>
</tr>
<tr>
<td>Axis 6</td>
<td>+/-2700°(340°/s)</td>
<td>+/-2700°(340°/s)</td>
</tr>
</tbody>
</table>

**Repeatability**

<table>
<thead>
<tr>
<th></th>
<th>+/- 0,06 mm 0.00236 in</th>
<th>+/- 0,06 mm 0.00236 in</th>
</tr>
</thead>
</table>

**Robot weight**

|                 | 685kg 1510.16 lb       | 680kg 1499.14 lb       |

**Tool coupling flange**

|                 | ISO 9409-1-A100        | ISO 9409-1-A100        |

**Motors**

|                 | AC brushless           | AC brushless           |

**Position measurement system**

|                 | with encoder            | with encoder            |

**Total power installed**

|                 | 12 kVA / 18.5 A        | 12 kVA / 18.5 A        |

**Protection class**

|                 | IP65 / IP67            | IP65 / IP67            |

**Working temperature**

|                 | 0 ÷ + 45°C             | 0 ÷ + 45°C             |

**Storage temperature**

|                 | - 40°C ÷ + 60°C        | - 40°C ÷ + 60°C        |

**Colour of robot (standard)**

|                 | Red RAL 3020            | Red RAL 3020            |

**Assembly position**

|                 | On the floor; from the ceiling; sloped (45° max) | On the floor; from the ceiling; sloped (45° max) |

(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 6-9

(*) Is available Foundry versions with degree IP67 for wrist and motors to guarantee protection in environments with high temperatures.
Tab. 3.2 - SMART NM off-set Characteristics and performance

<table>
<thead>
<tr>
<th>VERSION</th>
<th>NM 25-2.2 off-set (*)</th>
<th>NM 45-2.0 off-set (*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure / n° axes</td>
<td>Anthropomorphous / 6 axis</td>
<td>Anthropomorphous / 6 axis</td>
</tr>
<tr>
<td>Load at wrist</td>
<td>25kg (1) 55.11 lb (1)</td>
<td>45kg (1) 99.20 lb (1)</td>
</tr>
<tr>
<td>Additional load on forearm</td>
<td>40kg (2) 88.18 lb (2)</td>
<td>40kg (2) 88.18 lb (2)</td>
</tr>
<tr>
<td>Torque axis 4</td>
<td>176,58 Nm</td>
<td>176,58 Nm</td>
</tr>
<tr>
<td>Torque axis 5</td>
<td>176,58 Nm</td>
<td>176,58 Nm</td>
</tr>
<tr>
<td>Torque axis 6</td>
<td>98,1 Nm</td>
<td>98,1 Nm</td>
</tr>
<tr>
<td>Stroke / (Speed)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Axis 1</td>
<td>+/- 180° (160°/s)</td>
<td>+/- 180° (160°/s)</td>
</tr>
<tr>
<td>Axis 2</td>
<td>+/- 130°/-53° (150°/s)</td>
<td>+/- 130°/-53° (150°/s)</td>
</tr>
<tr>
<td>Axis 3</td>
<td>+/- 110°/-170° (160°/s)</td>
<td>+/- 110°/-170° (160°/s)</td>
</tr>
<tr>
<td>Axis 4</td>
<td>+/- 2700° (250°/s)</td>
<td>+/- 2700° (250°/s)</td>
</tr>
<tr>
<td>Axis 5</td>
<td>+/- 2700° (250°/s)</td>
<td>+/- 2700° (250°/s)</td>
</tr>
<tr>
<td>Axis 6</td>
<td>+/- 2700° (340°/s)</td>
<td>+/- 2700° (340°/s)</td>
</tr>
<tr>
<td>Repeatability</td>
<td>+/- 0.06 mm 0.00236 in</td>
<td>+/- 0.06 mm 0.00236 in</td>
</tr>
<tr>
<td>Robot weight</td>
<td>685kg 1510.16 lb</td>
<td>680kg 1499.14 lb</td>
</tr>
<tr>
<td>Tool coupling flange</td>
<td>ISO 9409-1-A100</td>
<td>ISO 9409-1-A100</td>
</tr>
<tr>
<td>Motors</td>
<td>AC brushless</td>
<td>AC brushless</td>
</tr>
<tr>
<td>Position measurement system</td>
<td>with encoder</td>
<td>with encoder</td>
</tr>
<tr>
<td>Total power installed</td>
<td>12 kVA / 18,5 A</td>
<td>12 kVA / 18,5 A</td>
</tr>
<tr>
<td>Protection class</td>
<td>IP65 / IP67</td>
<td>IP65 / IP67</td>
</tr>
<tr>
<td>Working temperature</td>
<td>0 + + 45°C</td>
<td>0 + + 45°C</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>- 40°C + + 60°C</td>
<td>- 40°C + + 60°C</td>
</tr>
<tr>
<td>Colour of robot (standard)</td>
<td>Red RAL 3020</td>
<td>Red RAL 3020</td>
</tr>
<tr>
<td>Assembly position</td>
<td>On the floor; from the ceiling; sloped (45° max)</td>
<td>On the floor; from the ceiling; sloped (45° max)</td>
</tr>
</tbody>
</table>

(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 6-9

(*) Is available Foundry versions with degree IP67 for wrist and motors to guarantee protection in environments with high temperatures.
### Tab. 3.3 - SMART NM 16-3.1 Characteristics and performance

<table>
<thead>
<tr>
<th>Structure / n° axes</th>
<th>NM 16-3.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load at wrist</td>
<td>16kg (1)</td>
</tr>
<tr>
<td></td>
<td>35.27lb (1)</td>
</tr>
<tr>
<td>Additional load on forearm</td>
<td>10kg (2)</td>
</tr>
<tr>
<td>Torque axis 4</td>
<td>41Nm</td>
</tr>
<tr>
<td>Torque axis 5</td>
<td>41Nm</td>
</tr>
<tr>
<td>Torque axis 6</td>
<td>23Nm</td>
</tr>
<tr>
<td>Stroke / (Speed)</td>
<td></td>
</tr>
<tr>
<td>Axis 1</td>
<td>+/- 180° (120°/s)</td>
</tr>
<tr>
<td>Axis 2</td>
<td>+130°/-53° (100°/s)</td>
</tr>
<tr>
<td>Axis 3</td>
<td>+110°/-170° (100°/s)</td>
</tr>
<tr>
<td>Axis 4</td>
<td>+/- 2700° (250°/s)</td>
</tr>
<tr>
<td>Axis 5</td>
<td>+/- 120° (350°/s)</td>
</tr>
<tr>
<td>Axis 6</td>
<td>+/- 2700° (340°/s)</td>
</tr>
<tr>
<td>Repeatability</td>
<td>+/- 0,1 mm</td>
</tr>
<tr>
<td>Robot weight</td>
<td>685 kg</td>
</tr>
<tr>
<td>Tool coupling flange</td>
<td>ISO 9409-1-A63</td>
</tr>
<tr>
<td>Motors</td>
<td>AC brushless</td>
</tr>
<tr>
<td>Position measurement system</td>
<td>with encoder</td>
</tr>
<tr>
<td>Total power installed</td>
<td>12 kVA / 18.5 A</td>
</tr>
<tr>
<td>Protection class</td>
<td>IP65 / IP67</td>
</tr>
<tr>
<td>Working temperature</td>
<td>0 + 45[°C]</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>- 40[°C] + 60[°C]</td>
</tr>
<tr>
<td>Colour of robot (standard)</td>
<td>Red RAL 3020</td>
</tr>
<tr>
<td>Assembly position</td>
<td>On the floor; from the ceiling; sloped (45° max)</td>
</tr>
</tbody>
</table>

(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 6-9
### Technical Characteristics

#### Tab. 3.4 - SMART NM 45-2.0 In-line Wash

**Characteristics and performance**

<table>
<thead>
<tr>
<th>VERSION</th>
<th>NM 45-2.0 In-line Wash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure / n° axes</td>
<td>Anthropomorphous / 6 axis</td>
</tr>
</tbody>
</table>
| Load at wrist | 45kg (1)  
99.19 lb (1) |
| Additional load on forearm | 40kg(2) |
| Torque axis 4 | 176,58 Nm |
| Torque axis 5 | 176,58 Nm |
| Torque axis 6 | 117,72Nm |
| Stroke (Speed) |  
Axis 1 \(\pm 180^\circ\) (160°/s)  
Axis 2 \(130^\circ/-53^\circ\) (150°/s)  
Axis 3 \(110^\circ/-170^\circ\) (160°/s)  
Axis 4 \(\pm -2700^\circ\) (250°/s)  
Axis 5 \(\pm -123^\circ\) (250°/s)  
Axis 6 \(\pm -2700^\circ\) (340°/s) |
| Maximum horizontal reach | 2000 mm  
(78.74 in) |
| Repeatability | \(\pm 0.06\) mm  
(0.00236 in) |
| Robot weight | 680 kg  
(1499.142 lb) |
| Tool coupling flange | ISO 9409-1-A100 |
| Motors | AC brushless |
| Position measurement system | con encoder |
| Total power installed | 12 kVA / 18.5 A |
| Protection class | IP67 |
| Working temperature | 0 \(+ 45[^\circ C]\) |
| Air humidity | 100% |
| The maximum pressure of the jet for the washing equipment | 600 bar |
| Storage temperature | - 40[^\circ C] \(+ 60[^\circ C]\) |
| Assembly position | On the floor; |

1) The robot is not to be directly exposed to the waterjet pressure.

The data contained in the table refers to the robot mechanics and does not include the control unit.
4. OPERATING AREAS AND ROBOT OVERALL DIMENSIONS

This chapter contains the drawings of the operating areas that can be obtained with SMART NM robots and drawings regarding the limitations of the resulting areas if mechanical limit switches are installed:

- SMART NM 25-2.2 In line - SMART NM 25-2.2 Foundry - Operating Area
- SMART NM 45-2.0 In line - SMART NM 45-2.0 Foundry Operating Area

- SMART NM 25-2.2 off-set - SMART NM 25-2.2 Foundry - Operating Area
- SMART NM 45-2.0 off-set - SMART NM 45-2.0 Foundry - Operating Area

- SMART NM 16 3.1 Operating Area

- SMART NM 25-2.2 In line - SMART NM 25-2.2 Foundry - Operating area limit
- SMART NM 45-2.0 In line - SMART NM 45-2.0 Foundry - Operating area limit

- SMART NM 25-2.2 off-set - SMART NM 25-2.2 Foundry Operating area limit
- SMART NM 45-2.0 off-set - SMART NM 45-2.0 Foundry Operating area limit

- SMART NM 16-3.1 Operating area limit

The operating areas are traced at the wrist centre.
SMART NM 25-2.2 In line
SMART NM 25-2.2 Foundry - Operating Area
### SMART NM 25-2.2 In line
### SMART NM 25-2.2 Foundry - Operating Area

<table>
<thead>
<tr>
<th>Joints in Calibration Position (pos.9)</th>
<th>Ax 1</th>
<th>Ax 2</th>
<th>Ax 3</th>
<th>Ax 4</th>
<th>Ax 5</th>
<th>Ax 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>0°</td>
<td>0°</td>
<td>-90°</td>
<td>0°</td>
<td>0°</td>
<td>0°</td>
<td>0°</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>[mm]</th>
<th>[mm]</th>
<th>[deg]</th>
<th>[deg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>567.4</td>
<td>279.47</td>
<td>+40°</td>
<td>-170°</td>
</tr>
<tr>
<td>2</td>
<td>179.47</td>
<td>-479.8</td>
<td>+130°</td>
<td>-110°</td>
</tr>
<tr>
<td>3</td>
<td>1810.61</td>
<td>-278.46</td>
<td>+130°</td>
<td>-13.24°</td>
</tr>
<tr>
<td>4</td>
<td>-832.15</td>
<td>2118.44</td>
<td>-42°</td>
<td>-13.24°</td>
</tr>
<tr>
<td>5</td>
<td>-870.33</td>
<td>532.86</td>
<td>-42°</td>
<td>+80°</td>
</tr>
<tr>
<td>6</td>
<td>-520.99</td>
<td>660.29</td>
<td>-15°</td>
<td>+110°</td>
</tr>
<tr>
<td>7</td>
<td>828.19</td>
<td>1570.32</td>
<td>+108.13°</td>
<td>+110°</td>
</tr>
<tr>
<td>8</td>
<td>861.13</td>
<td>941.79</td>
<td>-53°</td>
<td>-136.48°</td>
</tr>
<tr>
<td>9</td>
<td>1462.4</td>
<td>1750</td>
<td>0°</td>
<td>-90°</td>
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</table>
ART NMSMART NM 45-2.0 In line
SMART NM 45-2.0 Foundry Operating Area
SMART NM 45-2.0 In line
SMART NM 45-2.0 Foundry Operating Area

<table>
<thead>
<tr>
<th>Pos</th>
<th>X   [mm]</th>
<th>Z   [mm]</th>
<th>Ax.2 [deg]</th>
<th>Ax.3 [deg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>567,4</td>
<td>279,47</td>
<td>+40°</td>
<td>-170°</td>
</tr>
<tr>
<td>2</td>
<td>179,47</td>
<td>-479,8</td>
<td>+130°</td>
<td>-110°</td>
</tr>
<tr>
<td>3</td>
<td>1810,61</td>
<td>-278,46</td>
<td>+130°</td>
<td>-13,24°</td>
</tr>
<tr>
<td>4</td>
<td>-832,15</td>
<td>2118,44</td>
<td>-42°</td>
<td>-13,24°</td>
</tr>
<tr>
<td>5</td>
<td>-805,47</td>
<td>532,86</td>
<td>-42°</td>
<td>+80°</td>
</tr>
<tr>
<td>6</td>
<td>-520,99</td>
<td>660,29</td>
<td>-15°</td>
<td>+110°</td>
</tr>
<tr>
<td>7</td>
<td>828,19</td>
<td>1570,32</td>
<td>+108,13°</td>
<td>+110°</td>
</tr>
<tr>
<td>8</td>
<td>861,13</td>
<td>941,79</td>
<td>-53°</td>
<td>-136,48°</td>
</tr>
<tr>
<td>9</td>
<td>1462,4</td>
<td>1750</td>
<td>0°</td>
<td>-90°</td>
</tr>
</tbody>
</table>

Joints in Calibration Position (pos.9)

<table>
<thead>
<tr>
<th>Ax 1</th>
<th>Ax 2</th>
<th>Ax 3</th>
<th>Ax 4</th>
<th>Ax 5</th>
<th>Ax 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>0°</td>
<td>0°</td>
<td>-90°</td>
<td>0°</td>
<td>0°</td>
<td>0°</td>
</tr>
</tbody>
</table>
SMART NM 25-2.2 off-set
SMART NM 25-2.2 Foundry - Operating Area
SMART NM 25-2.2 off-set
SMART NM 25-2.2 Foundry - Operating Area

<table>
<thead>
<tr>
<th>Pos</th>
<th>X</th>
<th>Z</th>
<th>Ax.2</th>
<th>Ax.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>567.4</td>
<td>279.47</td>
<td>+40°</td>
<td>-170°</td>
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<tr>
<td>2</td>
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<td>-110°</td>
</tr>
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<td>3</td>
<td>1810.61</td>
<td>-278.46</td>
<td>+130°</td>
<td>-13.24°</td>
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<tr>
<td>4</td>
<td>-832.15</td>
<td>2118.44</td>
<td>-42°</td>
<td>-13.24°</td>
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<td>6</td>
<td>-520.99</td>
<td>660.29</td>
<td>-15°</td>
<td>+110°</td>
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<td>7</td>
<td>828.19</td>
<td>1570.32</td>
<td>+108.13°</td>
<td>+110°</td>
</tr>
<tr>
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<td>1462.4</td>
<td>1750</td>
<td>0°</td>
<td>-90°</td>
</tr>
</tbody>
</table>

Joints in Calibration Position (pos.9)

<table>
<thead>
<tr>
<th>Ax 1</th>
<th>Ax 2</th>
<th>Ax 3</th>
<th>Ax 4</th>
<th>Ax 5</th>
<th>Ax 6</th>
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</thead>
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<tr>
<td>0°</td>
<td>0°</td>
<td>-90°</td>
<td>0°</td>
<td>+90°</td>
<td>0°</td>
</tr>
</tbody>
</table>

Pos: X [mm], Z [mm], Ax.2 [deg], Ax.3 [deg]
SMART NM 45-2.0 off-set
SMART NM 45-2.0 Foundry - Operating Area
SMART NM 45-2.0 off-set  
SMART NM 45-2.0 Foundry - Operating Area

<table>
<thead>
<tr>
<th>Pos</th>
<th>X</th>
<th>Z</th>
<th>Ax.2</th>
<th>Ax.3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[mm]</td>
<td>[mm]</td>
<td>[deg]</td>
<td>[deg]</td>
</tr>
<tr>
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<td>526.21</td>
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<td>+70°</td>
<td>-170°</td>
</tr>
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<td>-15°</td>
<td>+110°</td>
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<tr>
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<td>1434.16</td>
<td>+88.43°</td>
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<td>1212.4</td>
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</table>

Joints in Calibration Position (pos.9)

<table>
<thead>
<tr>
<th>Ax 1</th>
<th>Ax 2</th>
<th>Ax 3</th>
<th>Ax 4</th>
<th>Ax 5</th>
<th>Ax 6</th>
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<td>0°</td>
<td>-90°</td>
<td>0°</td>
<td>+90°</td>
<td>0°</td>
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</table>
SMART NM 16 3.1 Operating Area
## SMART NM 16 3.1 Operating Area

### Table: Operating Areas and Robot Overall Dimensions

<table>
<thead>
<tr>
<th>Pos</th>
<th>X [mm]</th>
<th>Z [mm]</th>
<th>Ax.2 [deg]</th>
<th>Ax.3 [deg]</th>
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</thead>
<tbody>
<tr>
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<td>+45°</td>
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<td>+2468,32</td>
<td>-985,52</td>
<td>+130°</td>
<td>-9,28°</td>
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<td>4</td>
<td>-1756,31</td>
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<td>-53°</td>
<td>-9,28°</td>
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<td>0°</td>
<td>-90°</td>
</tr>
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</table>

### Joints in Calibration Position (pos.9)

<table>
<thead>
<tr>
<th>Ax 1</th>
<th>Ax 2</th>
<th>Ax 3</th>
<th>Ax 4</th>
<th>Ax 5</th>
<th>Ax 6</th>
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<td>0°</td>
<td>-90°</td>
<td>0°</td>
<td>0°</td>
<td>0°</td>
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</table>
SMART NM 25-2.2 In line  
SMART NM 25-2.2 Foundry - Operating area limit

(1) Operating area curve with stroke limitation  
(2) Standard Operating area curve without stroke limitation
SMART NM 45-2.0 In line
SMART NM 45-2.0 Foundry - Operating area limit

(1) Operating area curve with stroke limitation
(2) Standard Operating area curve without stroke limitation
SMART NM 25-2.2 off-set
SMART NM 25-2.2 Foundry
Operating area limit

(1) Operating area curve with stroke limitation
(2) Standard Operating area curve without stroke limitation
SMART NM 45-2.0 off-set
SMART NM 45-2.0 Foundry
Operating area limit

(1) Operating area curve with stroke limitation
(2) Standard Operating area curve without stroke limitation
SMART NM 16-3.1 Operating area limit

1. Operating area curve with stroke limitation
2. Standard Operating area curve without stroke limitation
5. ROBOT FLANGE

5.1 Tool coupling flange

This chapter contains a drawing of the tool connecting flange with the dimensions and distances between the holes used to connect the tool and the drawing of the Gauged Tool option. This option is used to calculate the exact flange center point when installing application-specific tools.

– Fig. 5.1 - SMART NM Tool connecting flange
– Fig. 5.1 - SMART NM Tool connecting flange
– Fig. 5.3 - SMART NM 16 - 3.1 Tool mounting flange
Fig. 5.1 - SMART NM Tool connecting flange

1. Tool locating pin
2. Gauged tool (code 81783801)
Fig. 5.2 - SMART NM off-set Tool mounting flange

1. Equipment centring pin
2. Calibrated tool (code 81783801)
Fig. 5.3 - SMART NM 16 - 3.1 Tool mounting flange

1. Calibrated tool (code 81783801)
6. LOADS AT WRIST AND ADDITIONAL LOADS

6.1 Overview

This chapter describes the procedures used to determine the maximum load that can be applied to the robot flange and any additional loads applied to the forearm.

- Load capacity on the flange according to the distance from the center of gravity
  - Fig. 6.3 - SMART NM 25-2.2 Maximum load capacity at the flange
  - Fig. 6.4 - SMART NM 45-2.0 Maximum load capacity at the flange
  - Fig. 6.5 - SMART NM 25-2.2 off-set Flange maximum payload
  - Fig. 6.6 - SMART NM 45-2.0 off-set Flange maximum payload
  - Fig. 6.7 - SMART NM 16-3.1 Flange maximum payload

- Areas where the center of gravity is allowed in relation to the additional load
  - Fig. 6.8 - SMART NM Position of center of gravity of additional loads

- Hole centers and dimensions for connecting any additional loads applied to the forearm of the robot.
  - Fig. 6.10 - SMART NM 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;
- \( L_Z \) = Distance of load P center of gravity from tool attachment flange surface (see diagram);
- \( L_{XY} \) = Distance of load P center of gravity from axis 6
- \( L_2 \) = Distance of axis 5 from tool attachment flange surface (see diagram).
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_XY and L_Z of the load center of gravity.

The area subtended by the load curves defines the distances from the center of gravity that are allowed for applying the specific load.
For loads or inertias other than those shown in the graphs, the following formulas can be used to plot a specific curve:

\[
\begin{align*}
Kz &= \frac{(a - 0.25 \times J_0)}{M} \\
L_1 &= 2000 \left[ -b + (c + Kz)^{0.5} \right] \\
Kxy &= \frac{(d - 0.25 \times J_0)}{M} \\
Lxy &= 2000 \times \left[ -e + (f + Kxy)^{0.5} \right]
\end{align*}
\]

where:
- \(a, b, c, d, e, f\) = numerical constants depending on the type of wrist (see Load Capacity graphs).
- \(J_0\) (kgm\(^2\)) = maximum moment of inertia at the center of gravity of the total load applied to the flange
- \(M\) (kg) = total mass applied to the flange
- \(L_2\) = distance of flange surface from axis 5 that corresponds to the center point of curve \(L_1\) (see diagram)

In any case the following conditions must be present:

\[
L_1 \leq H / M; Lxy \leq N / M
\]

where: \(H\) and \(N\) = numerical constants depending on the type of wrist
Fig. 6.3 - SMART NM 25-2.2 Maximum load capacity at the flange

1. (a) Weight
2. (b) Inertia

Numerical constants to be used in the formulas specified in Determination of max. loads at wrist flange (QF)
The inertia specified in the curves in the graph refers to the center of gravity of the load applied to the flange.

**Fig. 6.4** - SMART NM 45-2.0 Maximum load capacity at the flange

Numerical constants to be used in the formulas specified in *Determination of max. loads at wrist flange (QF)*
The inertia specified in the curves in the graph refers to the center of gravity of the load applied to the flange.

**Fig. 6.5 - SMART NM 25-2.2 off-set Flange maximum payload**

1. (a) Weight
2. (b) Inertia

Numeric constants to be applied to the formulas contained in Determination of max. loads at wrist flange (QF)
The inertia specified on the graph curves refers to the centre of gravity of the load applied on the flange.

**Fig. 6.6 - SMART NM 45-2.0 off-set Flange maximum payload**

1. (a) Weight
2. (b) Inertia

Numeric constants to be applied to the formulas contained in Determination of max. loads at wrist flange (QF)
a=8,709; b=0,225; c=0,051; d=3,600; e=0,198; f=0,039; 
H=18000; N=10000; L2 = 170mm

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

**Fig. 6.7**  -  SMART NM 16-3.1 Flange maximum payload

1. (a) Weight
2. (b) Inertia

Numeric constants to be applied to the formulas contained in Determination of max. loads at wrist flange (QF)
6.3 Additional loads (Qs)

Besides the load applied to the flange QF, an additional load Qs can be applied to the forearm of all robots except the SH version. The values for these loads are shown in Tab. 6.1 - Maximum loads that can be applied.

In each application, the centre of gravity of the load applied on flange QF is to be within the subtended area of the curves shown in the graphs in Fig. 6.3, Fig. 6.4, Fig. 6.7 furthermore, the centre of gravity of the additional load Qs is to be within the area of the graph of Fig. 6.8 - SMART NM Position of center of gravity of additional loads and Fig. 6.9 - SMART NM 16-3.1 Position of center of gravity of additional loads.

The holes on the forearm of the robot, illustrated in Fig. 6.10 - SMART NM Holes for connecting tools to the forearm, can be used to connect special tools to the robot.

<table>
<thead>
<tr>
<th>Max. total load</th>
<th>SMART NM 25-2.2</th>
<th>SMART NM 45-2.0</th>
<th>SMART NM 16-3.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. total load applied on the robot QT</td>
<td>65</td>
<td>85</td>
<td>26 kg</td>
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<tr>
<td>On flange QF</td>
<td>25kg</td>
<td>45kg</td>
<td>16kg</td>
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<tr>
<td>Additional load on forearm Qs</td>
<td>40kg</td>
<td>40kg</td>
<td>10kg</td>
</tr>
</tbody>
</table>

The inertia specified on the graph curves refers to the centre of gravity of the load applied on the flange.
Fig. 6.8 - SMART NM Position of center of gravity of additional loads

Fig. 6.9 - SMART NM 16-3.1 Position of center of gravity of additional loads
Fig. 6.10 - SMART NM Holes for connecting tools to the forearm
7. PREPARATIONS BEFORE INSTALLING THE ROBOT

Please read Chap.1. - General Safety Precautions before carrying out any installation operations.
The robot must be used with the C4G control unit. No other uses are allowed. Any exceptions to this rule must be expressly authorized by COMAU Robotics & Service.

7.1 Environment conditions

The robot is designed for use in the normal workshop environment. The robot wrist is manufactured to a high protection standard (IP67) so that it is suitable for applications in aggressive dusty environments where there are dust and very hot vapours, for example, handling parts in a foundry.

7.1.1 Environment data

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

7.1.2 Operating area

The maximum overall dimensions of the robot operating area are indicated on the graphs traced at the wrist centre in Chap. OPERATING AREAS AND ROBOT OVERALL DIMENSIONS in the TECHNICAL SPECIFICATIONS manual.

7.1.3 Fastening to a steel plate

The robot may be fastened to a specific steel plate with pre-engineered holes for the screws and pins; the screws and pins ass'y is available on request (see Fig. 7.1 - Screws and pins ass'y (on request)) the screws and pins required to secure the robot are optionals.

7.1.4 Fastening to a leveling plate (on request)

A specific assembly, consisting of 4 mounting plates that are anchored to the floor and a steel plate that is fastened to the robot and can be levelled by means of suitable screws, is available on request (see Leveling plate assembly del Chap. OPTIONAL EQUIPMENT in the TECHNICAL SPECIFICATIONS manual).
Preparations before Installing the Robot

Fig. 7.1 - Screws and pins ass'y (on request)

1. Location Ø = 30 mm L = 80 mm (q.ty = 1)
2. Location Ø = 30 mm L = 60 mm (q.ty = 1)
3. M 10 x 90 (8.8) socket head cap screw (q.ty = 1)
4. M 10 x 70 (8.8) socket head cap screw (q.ty = 1)
5. M 20 x 80 (8.8.) partially threaded hex head cap screw (q.ty = 4)
6. Split spring washer Ø = 20mm (q.ty = 4)
7. Flat washer Ø = 20 mm (q.ty = 4)
7.2 Stresses at the supporting structure

The robot base-plate must not be affected by vibrations caused by other machinery (e.g. hammers, presses, etc.).

In view of the considerable stresses produced by the robot on the floor, and the need to ensure suitable supports, robots are not designed to be anchored directly to the floor.
The robot must be fastened to a horizontal mounting plate.

Fig. 7.2 - Stresses at the supporting structure

<table>
<thead>
<tr>
<th>Floor installation</th>
<th>Ceiling installation</th>
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</thead>
<tbody>
<tr>
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</table>

<table>
<thead>
<tr>
<th>SMART NM; SMART NM off-set; SMART NM Wash</th>
</tr>
</thead>
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<tr>
<td>Robot movement</td>
</tr>
<tr>
<td>----------------</td>
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<tr>
<td>Accelerating</td>
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<tr>
<td>Emergency braking</td>
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</table>

<table>
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<tr>
<th>SMART NM16 3.1</th>
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</thead>
<tbody>
<tr>
<td>Robot movement</td>
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</tr>
<tr>
<td>Accelerating</td>
</tr>
<tr>
<td>Emergency braking</td>
</tr>
</tbody>
</table>
7.3 Robot installation on a sloped surface

The robot can be mounted on a sloped surface max 45° (see Fig. 7.3). In this case the stroke of axis 1 will be restricted as shown in the graph of Fig. 7.4 - SMART NM; SMART NM off-set; SMART NM wash- Axis 1 stroke limitation with robot mounted on a sloped surface.

For example, with the robot mounted on a surface sloped by 40° the rotation of axis 1 will be limited to ± 30°.

Fig. 7.3 - Robot installation on a sloped surface
Fig. 7.4 - SMART NM; SMART NM off-set; SMART NM wash-
Axis 1 stroke limitation with robot mounted on a sloped
surface
Fig. 7.5 - SMART NM 16 3.1 Axis 1 stroke limitation with robot mounted on a sloped surface
8. OPTIONAL EQUIPMENT

8.1 Overview

Before starting any type of installation operation, carefully read Chap.1. - General Safety Precautions. The robot has to be connected to the C4G control unit. No other use is permitted. Any exception is to be specifically authorised by COMAU Robotics & Service.

Tab. 8.1 - Applicability of options

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>NM</th>
<th>NM off set</th>
<th>NM 16 3.1</th>
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<tbody>
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<td>82212100</td>
<td>Axis 1 adjustable mechanical stop (code 82212100)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>82212200</td>
<td>Axis 2 adjustable mechanical stop (code 82212200)</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>82212300</td>
<td>Axis 3 adjustable mechanical stop (code 82212300)</td>
<td>1</td>
<td></td>
<td></td>
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<tr>
<td>CR82213400</td>
<td>Axis 1 work area sectoring assembly (code CR82213400)</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>81783801</td>
<td>Gauged tool assembly (code 81783801)</td>
<td>1</td>
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<td></td>
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<tr>
<td>82212400</td>
<td>Manual calibration kit SMART NM-NM off set (code 82212400)</td>
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<td>1</td>
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<tr>
<td>82282100</td>
<td>Manual calibration kit SMART NM 16 3.1 (code 82212100)</td>
<td>-</td>
<td>1</td>
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<td>82212700</td>
<td>Leveling plate assembly (code 82212700)</td>
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<td>Fork liftable assembly (code 82212600)</td>
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<td>82284200</td>
<td>Distribution connections protection assy (walkable code 82284200)</td>
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<td></td>
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<td>Set of screws and pins to secure robot (code 82211900)</td>
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<tr>
<td>82212400</td>
<td>Manual calibration kit</td>
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<td></td>
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<tr>
<td>82282100</td>
<td>Manual calibration kit</td>
<td>-</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
8.2 Axis 1 adjustable mechanical stop (code 82212100)

8.2.1 Description

The axis 1 adjustable mechanical stop assembly can be used to limit the stroke of axis 1 in both directions of work with steps of 22.5°. The assembly consists of two mechanical stops 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 mechanical stops to limit the stroke in one direction only. The axis 1 adjustable mechanical 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 stop and fastening screws;
- rubber stop blocks and fastening screws.

The parts of the robot concerned must also be checked for any damage, e.g.:
- 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.
8.3 Axis 2 adjustable mechanical stop (code 82212200)

8.3.1 Description

The axis 2 adjustable mechanical 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 +115° or +100° (instead of the standard +130° stroke) and the negative stroke can be limited to -38° or -23° (instead of the standard -53° stroke).

The axis 2 adjustable mechanical 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.
1. Stop block (q.ty 2)
2. Stop block (q.ty 2)
3. M10 x 20 socket head cap screw (cl 8.8) (q.ty 16)
4. Bracket (q.ty 4)
   a. Optional limit stop
   b. Standard limit stop
8.4 Axis 3 adjustable mechanical stop (code 82212300)

8.4.1 Description

The purpose of the axis 3 adjustable mechanical stop assembly is to prevent the forearm from overturning by preventing this from entering the work area behind the robot.

The assembly consists of a block that is fastened to the side of the body of the forearm using the screws and pin supplied with the robot: in case of an impact the stop block comes into contact with the fixed block that is always present on board the robot arm.

Axis 3 has a working stroke of between 0° and -170° while the blocked stroke is from 0° to +110°.

The axis 3 adjustable mechanical 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 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.
1. Stop block (q.ty 2)
2. M10 x 20 socket head cap screw (cl 8.8) (q.ty 8)
8.5 **Axis 1 work area sectoring assembly**
(code CR82213400)

8.5.1 **Descrizione**

The shutting of the axis 1 working stroke depends on the robot operating cycle. The axis 1 work area partialization assembly enables electrical partialization of up to 2 work areas, each of which is controlled by two safety micro-switches built to the strictest safety standards.

The assembly consists of:
- a 4-pushbutton multiple micro-switch with connector INTERCONTEC,
- a set of plastic cams to be cut to the length required for the specific application.

The cams must be inserted and blocked on the cam holders fastened to the robot by means of the specific supports.

The free connector is supplied for the external connection.

The kit includes:
- Nr. 1 connector INTERCONTEC 19 pins, type ASDA279FR92590035000;
- Nr. 3 female contacts from 1,5 mm to be crimped, for wires from 17 AWG;
- Nr. 16 female contacts from 1 mm to be crimped, for wires from 17 AWG;
- Nr. 1 cable clamp for cables from Ø 14 mm² to Ø 17 mm².

To crimp the female pins onto the wires from AWG 17 it is recommended to use the medium cross section INTERCONTEC "crimping tool" or an equivalent.

For the micro internal assembly electrical diagram, see the robot Circuit Diagram.
1. 4-track r.h. cam carrier
2. 4-track l.h. cam carrier
3. Plate
4. Cam
5. 4-roller microswitch
6. Screw, soc. hd cap (stub screw) M6x10 (8.8)
7. Screw, soc. hd cap M6 x 16-8.9
8. Parallel pin, D 4X20
9. Screw, soc. hd cap M6 x 20
10. Soc. grub screw, M6x8
11. Hex.nut, low-type M6
Tab. 8.2 - Electrical characteristics of axis 1 mechanical limit switch assembly

<table>
<thead>
<tr>
<th>ELECTRICAL DATA</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Type of switch</td>
<td>BSE 85 for DIN EN 60204-1</td>
</tr>
<tr>
<td>Insulation</td>
<td>Group C (VDE 0110)</td>
</tr>
<tr>
<td>Maximum voltage</td>
<td>50 Vac</td>
</tr>
<tr>
<td>Maximum current</td>
<td>2 A</td>
</tr>
<tr>
<td>Minimum load</td>
<td>≥ 20 mA</td>
</tr>
<tr>
<td>Contact resistance</td>
<td>&lt; 40 mΩ</td>
</tr>
<tr>
<td>Interruption current</td>
<td>2 A, cos ϕ=0,8</td>
</tr>
</tbody>
</table>
8.6 Leveling plate assembly (code 82212700)

8.6.1 Description

The leveling robot mounting 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
– the robot can be assembled using a spirit level to 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 16 anchor bolts that 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 -8.6 Leveling plate assembly (code 82212700)

1. Leveling plate (q.ty =1)
2. Plate (q.ty = 4)
3. Straight edge (q.ty = 8)
4. M20x 100 FULLY THREADED hex head cap screw-CL 8.8 (q.ty = 4)
5. M20 -8 FE/ZN 1/2 hex nut (q.ty = 4)
8.7 Manual calibration kit

<table>
<thead>
<tr>
<th>SMART NM-NM off set (code 82212400)</th>
<th>SMART NM 16 3.1 (code 82212100)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Diagram of the dial indicator holder and support" /></td>
<td><img src="image2" alt="Diagram of the manual calibration kit" /></td>
</tr>
<tr>
<td>1. Dial indicator holder</td>
<td>1. Dial indicator holder</td>
</tr>
<tr>
<td>2. Support for dial indicator holder on axis 5-6</td>
<td>2. Support for dial indicator holder on axis 5-6</td>
</tr>
</tbody>
</table>

**8.7.1 Description**

The manual calibration kit consists of the following parts:

- a dial indicator holder (1) that is screwed into the specific seats on axes 1-2-3-4.
- one support for the dial indicator holder that is screwed into the specific seats on axes 5-6.

To use the kit a centesimal dial gauge is necessary, to be screwed on the fixture (1). The kit is used to find the calibration position that corresponds to the position of the minimum reading on the dial gauge, with reference to the preset indexes in each robot axis.
**Tab. 8.3 - Example of the kit used to calibrate axis**

<table>
<thead>
<tr>
<th>Step</th>
<th>Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Removal of the guards (A and B) from the calibration reference surfaces</td>
<td><img src="image1.png" alt="Image" /></td>
</tr>
<tr>
<td>Visual alignment of calibration reference surfaces (C) and assembly of the dial indicator holder (D).</td>
<td><img src="image2.png" alt="Image" /></td>
</tr>
<tr>
<td>Finding the axis calibration point</td>
<td><img src="image3.png" alt="Image" /></td>
</tr>
</tbody>
</table>
### Tab. 8.4 - Example for use of axis 5 calibration kit

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a.</strong> Visual alignment of calibration reference surfaces, assembly of dial-gauge holder fixture and dial gauge.</td>
<td><strong>SMART NM</strong></td>
</tr>
<tr>
<td><strong>b.</strong> Finding the axis 5 calibration point.</td>
<td><strong>SMART NM 16-3.1</strong></td>
</tr>
</tbody>
</table>
Tab. 8.5 - Example for use of axis 6 calibration kit

<table>
<thead>
<tr>
<th>a. Visual alignment of calibration reference surfaces, assembly of dial-gauge holder fixture and dial gauge.</th>
<th>SMART NM</th>
</tr>
</thead>
<tbody>
<tr>
<td>b. Finding the axis 6 calibration point.</td>
<td>SMART NM 16 3.1</td>
</tr>
</tbody>
</table>
8.8 Gauged tool assembly (code 81783801)

8.8.1 SMART NM

1. Gauged tool
8.8.2 SMART NM off set

1. Gauged tool
8.8.3 SMART NM 16-3.1

8.8.4 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.
8.9 Fork liftable assembly (code 82212600)

8.9.1 Description

The fork liftable assembly is essential in order to hoist the robot using a fork lift truck. The assembly can be mounted so that the forks enter from the rear or the side of the robot. The assembly consists of a rectangular electrowelded structure made of structured steel that is fastened to the robot by means of screws.
8.10 Distribution connections protection assy (walkable code 82284200)

8.10.1 Description

The assembly consists of a robust sheet metal guard that is fastened to the robot base to protect all the connectors of the robot distribution assy.

8.11 Set of screws and pins to secure robot (code 82211900)

8.11.1 Description

The set contains the screws and pins needed to secure the robot to the steel base-plate of the robot.

For further information see Chap.7. - Preparations before Installing the Robot
1. Centring Ø = 30 mm L = 80 mm (qty = 1)
2. Centring Ø = 30 mm L = 60 mm (qty = 1)
3. Socket head cap screw M 10 x 90 (8.8) (qty = 1)
4. Socket head cap screw M 10 x 70 (8.8) (qty = 1)
5. Partially threaded hex head screws M 20 x 80 (8.8) (qty = 4)
6. Split spring washers Ø = 20mm (qty = 4)
7. Flat washers Ø = 20 mm (qty = 4)