


<b>ETN007</b> EN July 2013	<b>Mechanical, pneumatic and hydraulic design of equipment</b>	 JOINTLY INNOVATIVE
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01	500000009972	2018-03-06	D.CONZELMANN	2018-03-08	A.KUENSTLE	2018-03-08	U.KAMPHAUS
DOC-VER.	CHANGE NO.	EDITED		CHECKED		RELEASED	
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## 1 Purpose and Scope

**This company standard is currently valid for ETO MAGNETIC GmbH.**

This equipment specification (ES) is a guideline for the mechanical, pneumatic and hydraulic design of facilities and machines, henceforth denoted as mechanical design. This equipment specification shall be applicable to all orders placed by ETO. The technical design is examined during machine acceptance testing using a checklist.

In case of contradiction between this equipment specification and the specifications sheet, the design in the specifications sheet shall be applicable.

If special agreements are made, these shall only apply to the relevant order and shall be documented in writing. Oral agreements shall not apply.

If during acceptance testing, deviations from the equipment specification are detected, the observance of which would have been possible, a modification at supplier's expense may be requested.

The aim of this equipment specification is the following:

- High availability (operational availability) of the machine.
- Minimum spares inventory due to the use of suitable preferred components.
- Short downtimes during repairs due to the use of suitable preferred components.
- Avoid additional work and costs during start-up.
- Ensure safety for the operating and service personnel.
- Ensure use of modern technology in respect of cost effectiveness, maintenance and set-up times.
- Due to the described standardization and equipment identification in the equipment specification, ETO personnel can familiarize themselves quickly with new machines/systems.

## 2 Change history

Issue	Change Description
November 2014	Translation of the German version July 2013

## 3 Project Organization and Project Management

At ETO, the relevant technical department is responsible for the technical assessment and the design of mechanical facilities during procurement.

All drawings and project planning documents shall be presented to ETO for viewing and approval purposes on the occasion of the design discussion. The approval only relates to the design principle. This shall not release the supplier from their obligation to produce a fully functional machine which meets the technical specification as well as the applicable standards and laws.

Project planning documents include:

Machine-/system concept

- layout
- mechanical
- pneumatic
- hydraulic
- safety concept

Assembly drawings

Operation chart

NOK strategy

Cycle time calculation

Technical modifications arising during production and project planning shall be agreed upon with ETO.

The supplier acts as general contractor. The supplier is also responsible for all interfaces and processes.

The supplier shall find out about the local conditions. ETO may assist in providing information on the conditions such as e.g. how the machine may be installed, energy supply as well as arrangement and configuration of assemblies such as e.g. feeding systems.

Acceptance testing of the mechanical equipment as well as the installation is performed according to the specifications sheet.

The supplier shall complete the "Equipment Acceptance - Mechanical Devices" checklist and document the results. ETO will perform random sampling.

## 4 Specifications, standards and monitoring provisions

The Directive 2006/42/EC On Machinery shall be applicable.

The supplier shall be responsible for the safe operation of mechanical facilities and compliance with the standards and guidelines applicable at the time of operation acceptance.

If there is a monitoring obligation in effect for the operator of the scope of supply (ETO) according to legal requirements, the supplier shall notify ETO of this fact.

If components of the scope of supply require monitoring according to legal requirements, the supplier shall notify ETO of this fact.

## 5 Technical Documentation

The following documents shall be provided by the supplier as a single hardcopy and on an electronic data storage medium (e.g. CD, DVD, USB stick) together with the equipment:

- Manual
- Specifications of the equipment

Machine layout/installation plan including dimensions

Packaging, transport and installation instruction

Operating manual

Description of process sequence

Hydraulic plans

Pneumatic plans

Data sheets, technical documents and/or operating manuals for the components and parts used (in alphabetical order by supplier names)

Spare and wear parts lists as well as drawings in PDF form

Complete list of parts of the supplier

Set-up plans for product-dependent interchangeable parts

EC declaration of conformity / EC set-up declaration

Risk assessment according to machine specification

CAD data for every special equipment such as stations, structural units, tools, fixtures and single parts as well as associated parts lists, preferably as Autodesk Inventor 2D (IDW/DWG) data, drawings as PDF and 3D (IPT and IAM) data, alternatively original 3D-CAD files as well as 3D data as Step, 2D drawings as original CAD files as well as in PDF, DXF or DWG format.

Every document shall comply with the current status of the machine. If documents are subject to authority approval (e.g. for facilities requiring reporting and monitoring such as pressure tanks) the supplier is obligated to obtain the test certificate from the relevant authority prior to handing over the machine to ETO and present them to ETO upon delivery. In case of light grids, guard doors without guard control, two-hand controls and safety shut-down mats etc., the certificate of the passed stop-time measurement test shall be included. The actuators relevant for the stop-time measurement shall be described in detail.

## **6 Environment, ambient conditions**

### **6.1 Ambient temperature**

The mechanical and electrical equipment shall operate flawlessly at ambient temperatures between +10°C and +40°C. In case of machines for very hot or extremely cold environments, suitable measures shall be taken.

### **6.2 Air humidity**

The mechanical and electrical equipment shall operate flawlessly at a relative humidity of 50% and a maximum ambient temperature of +40°C. Higher relative humidity may be acceptable with lower ambient temperatures. Detrimental effects caused by condensation shall be prevented by taking suitable measures when designing the equipment or as required.

### **6.3 Hazardous materials**

The use of prohibited substances is not permitted. The supplier shall evaluate whether hazardous materials can be substituted by less hazardous materials.

All materials presenting direct or indirect hazards to the environment shall be notified to ETO during the design discussion at the latest and be approved in writing by ETO. Furthermore, the handling of such materials including application, use and disposal shall be described in writing.

If liquids are used, collecting trays shall be provided on principle.

Vapors shall be exhausted. The supplier shall clarify whether the central exhaust system at ETO may be used. Solvent vapors or explosive dusts shall be removed by means of a separate exhaust system.

### **6.4 Energy Saving, recycling**

When selecting the components and modules for the machines, the supplier shall plan for energy saving when it comes to the energy consumption. The loads shall be designed in an optimal way as regards energy efficiency. Overdimensioning shall be avoided for reasons of energy efficiency.

Machine components, such as e.g. feeding systems, feeder bowls, conveyor roads, exhaust systems etc. shall be shut off during idle time of the machine / cabinet according to freely configurable time parameters. Additional vacuum devices shall be activated as required. Feeding systems and feeder bowls shall only feed as required. The time shall be adjustable via the control panel.

The materials used shall be recyclable. A suitable identification shall be present on the components.

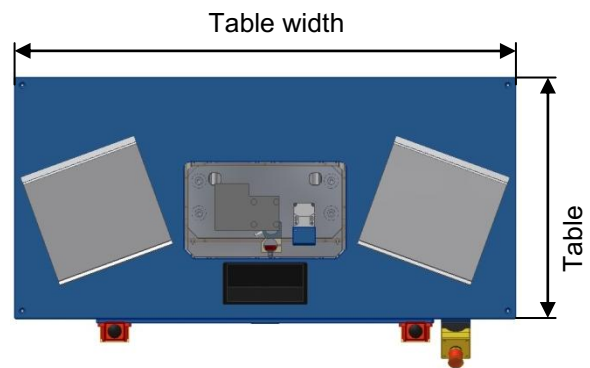
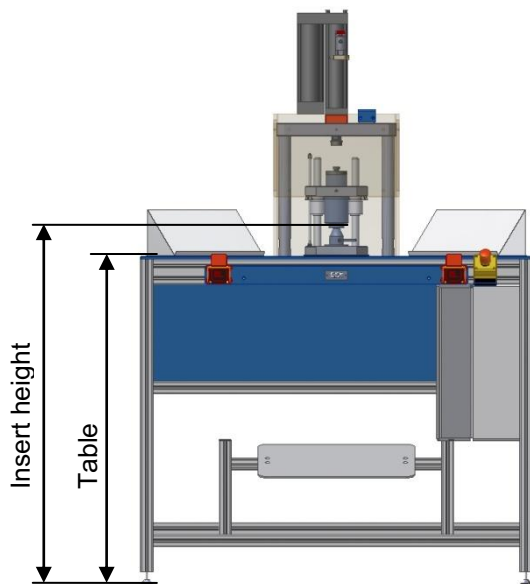
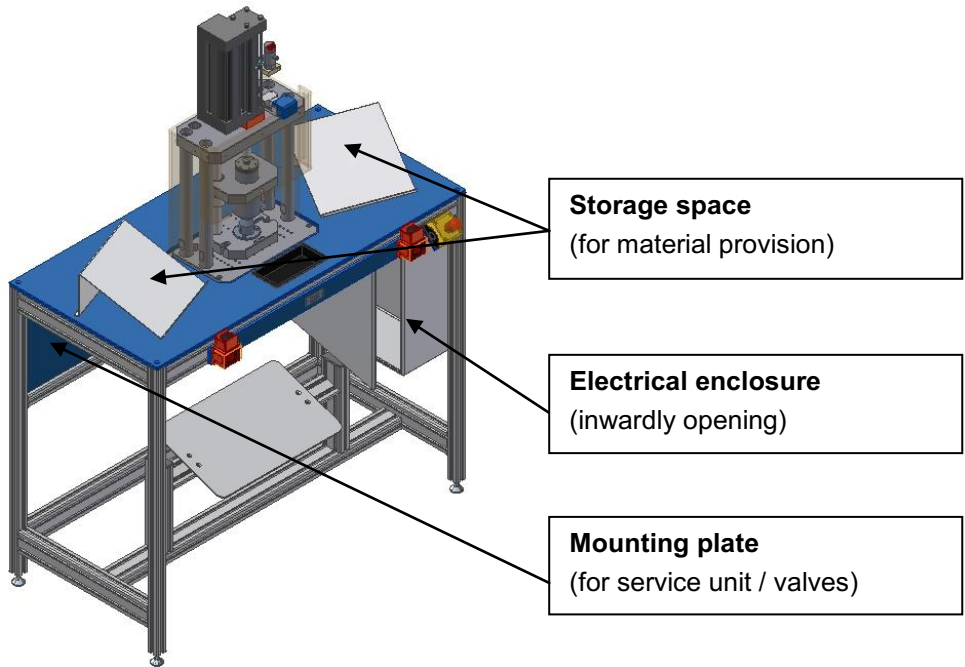
### **6.5 Noise emission of the equipment**

The equipment shall be designed and built according to the EC Machine Directive in such a fashion that the noise emission is as low as technically feasible.

## 7 Machine types

### 7.1 Manual workplace

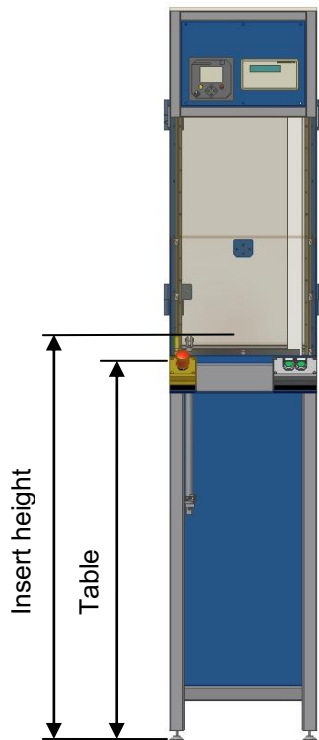
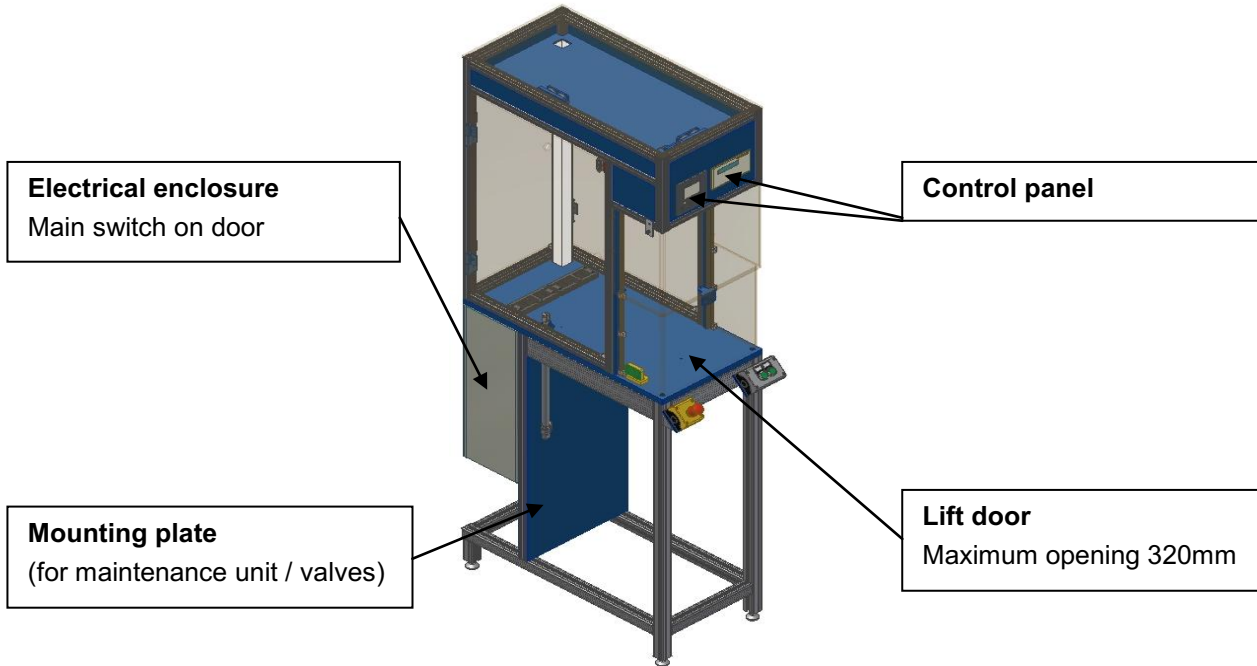
Example:



Dimensions	Value
<b>Table width:</b>	1000 mm
<b>Table depth:</b>	600 mm
<b>Table height:</b>	1050 mm (location China: 900 mm)
<b>Insert height:</b>	approx. 1150 mm - 1250 mm (location China: 1000 mm - 1100 mm)
<b>Machine height:</b>	max. 2500 mm

## 7.2 Lean workplace

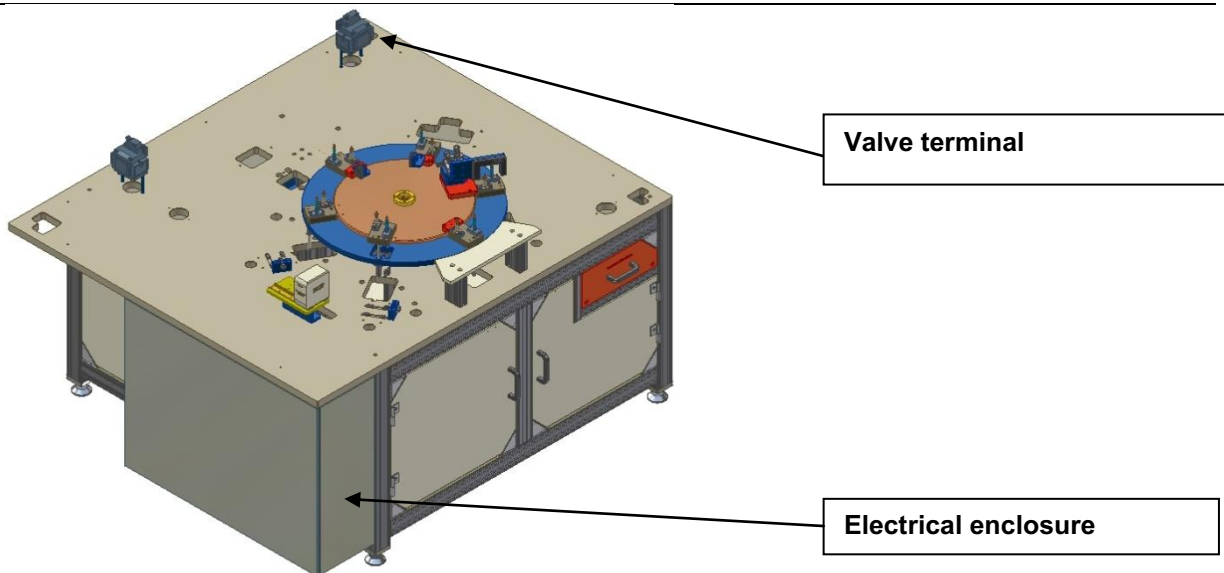
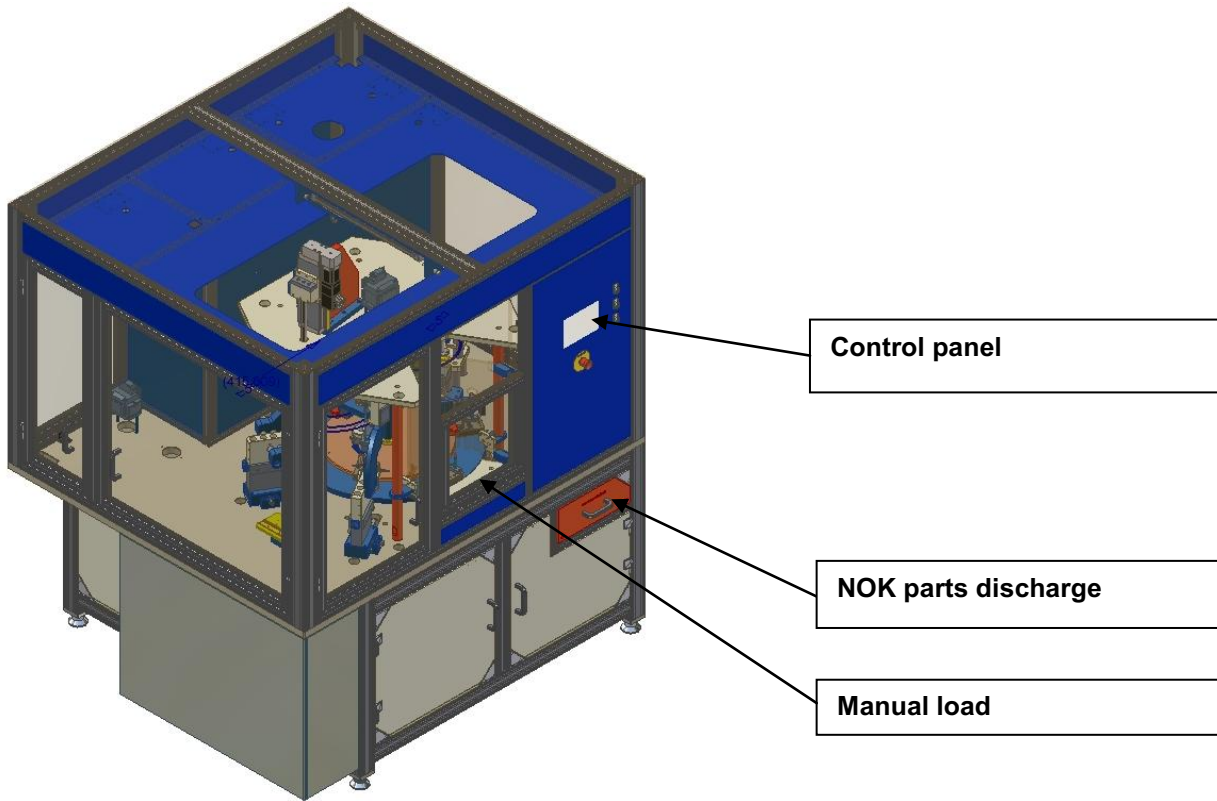
Example:



Dimensions	Value
<b>Table width:</b>	400 mm / 500mm / 600mm
<b>Table depth:</b>	800 mm
<b>Table height:</b>	1050 mm
<b>Insert height:</b>	approx. 1150mm – 1250mm
<b>Machine height:</b>	max. 2500 mm

### 7.3 Rotary indexing machine

Example:



Dimensions	Value
Table width:	max. 2300 mm (Observe transport limits!)
Table depth:	max. 2300 mm (Observe transport limits!)
Insert height:	approx. 1150 mm – 1250mm
Machine height:	max. 2500 mm
Control panel height:	Panel center: 1550mm ±30mm

## 7.4 Interlinked machines

<b>Dimensions</b>	<b>Value</b>
<b>Line length:</b>	max. 18,000 mm
<b>Line width:</b>	max. 3,500 mm
<b>Height of parts transfer (top edge of transfer belt):</b>	approx. 1000 mm
<b>Machine height:</b>	max. 2500 mm
<b>Control panel height:</b>	Panel center: 1550mm ±30mm

## 8 General requirements

### 8.1 Force and form closure / Poka-yoke

All parts and assemblies shall be positioned and fastened relative to each other using alignment pins. Please observe Poka-yoke. (Ex.: 1x bore  $\text{Ø}4^{\text{H7}}$ , 1x bore  $\text{Ø}5^{\text{H7}}$  and additionally a non-symmetrical bore alignment)

Bolts located in the insert area of the operator shall be countersunk. Assemblies which are aligned relative to each other shall have suitable adjusting mechanisms (e.g. adjustment slides, sliding blocks, adjustment screws, etc.).

### 8.2 Media connections

#### 8.2.1 Connection via supply beams

The media connections (cooling water, exhaustion, air supply 6 bar / 16 bar) shall leave the machine/system at the top.

The supply beams at ETO are mounted at a height of 2.70 m above ground.

The required connecting materials such as connectors, hose couplings etc. are part of the scope of supply of the machine.

Detailed agreements shall be made with the project manager.

In case of idle time of the machine, the supply lines for exhaust air and compressed air shall be shut off (time can be adjusted via control panel).

#### 8.2.2 Supply of lines

At ETO, the supply duct shall be installed at the side, outside of the cabinet for cleaning and accessibility reasons. The supply duct shall be covered in a slip-free manner. The cable duct type shall be specified upon agreement with ETO.

In case of lines with separate media distribution, the distribution of media shall be agreed upon with the project manager and the technical departments. ETO shall be informed about the type and quantity of connections after the design has been approved and the schedule for the installation shall be agreed upon. The transfer location shall be above the machine.

The following media, amongst others, shall be distributed in the machine:

- electricity
- compressed air (6 bar, 16 bar)
- exhaust air
- circuit
- cooling water
- inert gas

A pneumatic quick coupling for the connection of a suction gun shall be provided at the front and back of each cabinet.

### 8.3 ESD requirements

Every machine component, including the basic structure, shall be electrically linked. The work plates as well as the feet shall be electrostatically discharging.

## 8.4 Production parts for machines and materials

Production parts for machines shall preferably be standard parts. If standard parts are changed, drawings shall be prepared and included in the machine documentation.

The following materials and treatments shall be used for production parts for machines:

Use	Materials	Treatment
Steel parts subject to low to medium stresses.	1.0570; 1.0715; 1.1730	Hardening, Tenifer treatment, black-finishing, galvanizing, nickel-plating
Steel parts subject to medium to high stresses.	1.2842; 1.2080; 1.2436	Hardening, Tenifer treatment
Steel parts subject to high stresses.	1.2379 ; 1.2436	Hardening, Tenifer treatment
Steel parts made of special steel	1.4301, 1.4305, 1.4401, 1.4375	etched
Aluminum parts subject to low to medium stresses.	3.3547 (HABA G-Alu25)	Anodizing ("natural" color)
Aluminum parts subject to medium to high stresses.	3.3547 (HABA Alu28)	Anodizing ("natural" color)
Aluminum parts subject to high stresses.	3.3547 (HABA Alu-35)	Anodizing ("natural" color), hard anodizing

All parts shall be corrosion resistant.

## 8.5 Coloring of the machines

The following colors are acceptable for production parts for machines, such as e.g. welded frames and covers:

No.	Description
<b>Blue</b>	RAL 5007 Brilliant Blue RGB 87/101/151
<b>Light grey</b>	RAL 7035 Light Grey RGB 209/187/206

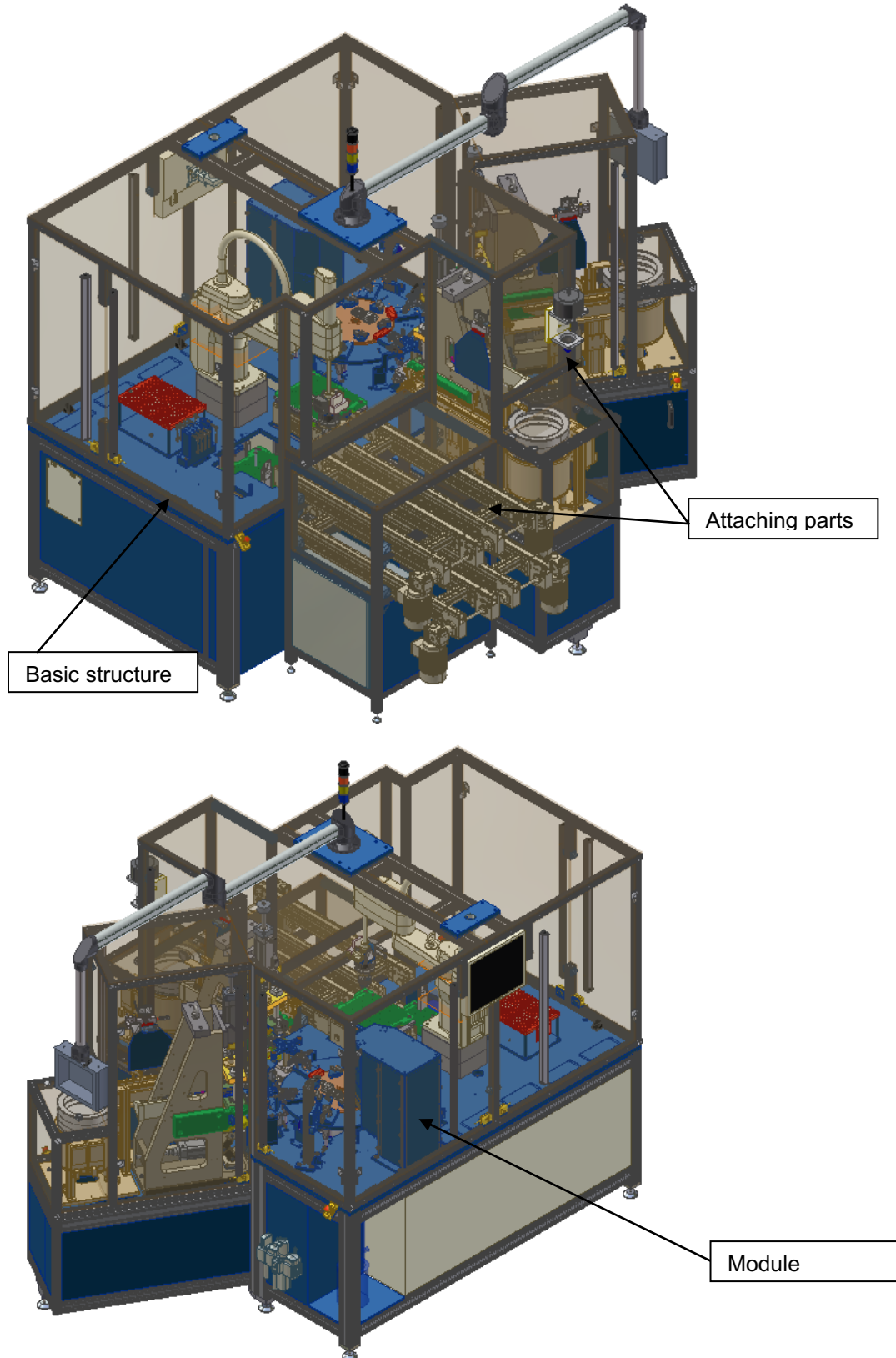
Note:

No adhesive labels (logo) by the machine manufacturer may be attached to the machine. This is only permissible on the identification plate.

## 9 Basic structure / strength of machines/systems

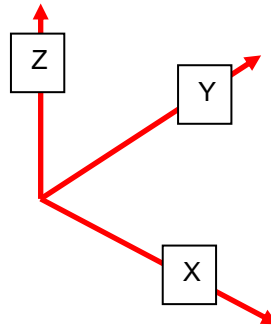
A machine is basically classified into a basic structure having modules mounted on it as well as attaching parts, such as e.g. feeder systems.

Modules and attaching parts shall be designed such that vibrations and shocks do not have an impact on mounting or testing processes.



## 9.1 Definition of machine coordinates

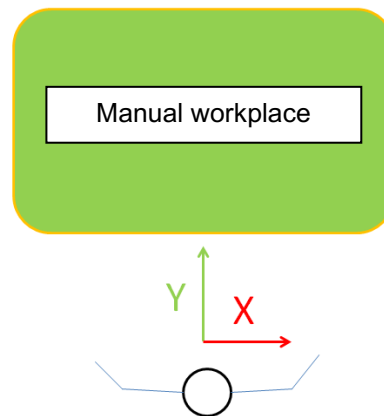
The machine coordinates are defined according to the "right-hand rule". The arrows point in positive directions. As a rule, the axial direction shall be selected such that the use of positive values is possible.



Axes of rotation are identified by a C and a directional index. E.g. an axis of rotation parallel to the x-axis is named Cx. The positive direction of rotation is based on the right-hand rule (The thumb points in the positive axial direction, the curled fingers point in the positive direction of rotation.).

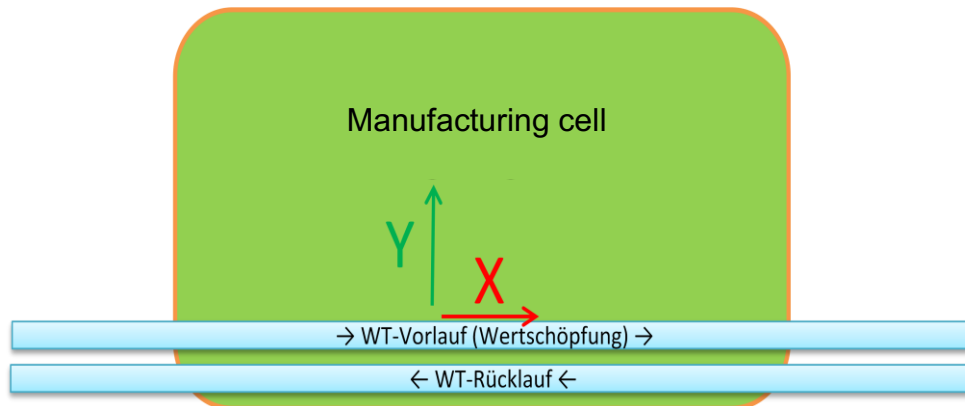
### 9.1.1 Manual workplaces

X-axes are all axes running horizontally and to the side from the worker's point of view. Y-axes are all axes running horizontally and ahead from the worker's point of view. Z-axes are all vertical axes.



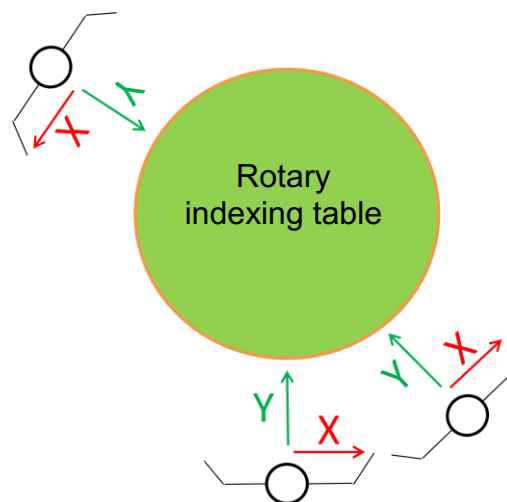
### 9.1.2 Automated lines

In case of automated lines, the coordinate definition is based on the direction of travel of the workpiece carrier. The positive x axis complies with the direction of travel of the workpiece carrier.



### 9.1.3 Rotary indexing machine

In case of a rotary indexing machine, the y-axis points in positive direction to the axis of rotation of the rotary indexing table.



## 9.2 Base frame and base plates

Machine frames shall be designed such that the machine/system does not distort during transport. After the transport of a machine, adjustment work must not be required.

In case of machines with highly dynamic drive systems and/or components with high dead weights

1. base plates made of steel, at least 30 mm thick, nickel-plated and having a steel welded base frame shall be used or
2. base plates made of steel, at least 40 mm thick, nickel-plated and having a base frame made of "80x80 heavy" aluminum sections shall be used.

In case of all other machines, base plates made of aluminum, at least 20 mm thick, "natural"-color anodized shall be used. The base frame shall be designed with 40x40 aluminum sections.

Separated base plates shall not be used, if possible.

Screwing the machine to the shop floor is not permitted at ETO.

## 9.3 Pneumatic design

### 9.3.1 Design pressure

The design pressure for the calculation of pneumatic drives shall be at least 0.5 bar below the nominal pressure specified by ETO, e.g.

Nominal pressure according to ETO:  $p = 5.0$  bar

Design pressure:  $p = 4.5$  bar

Note: The standard pressure is 5.5 bar.

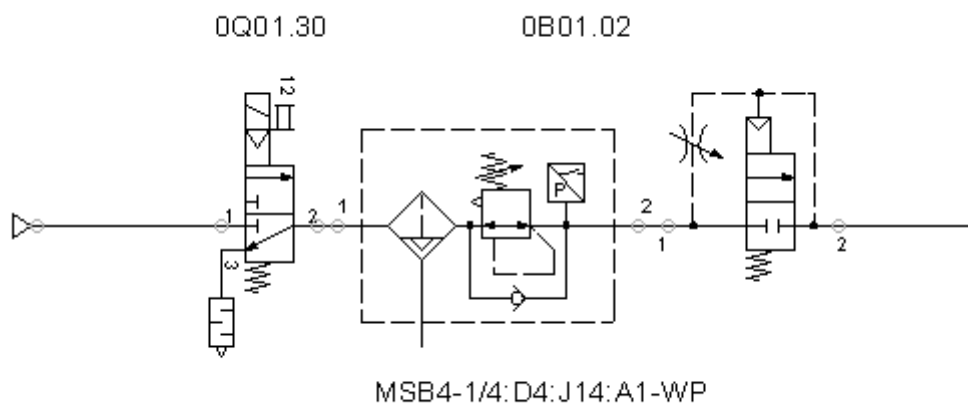
### 9.3.2 Design reserve

All pneumatic movements shall have a design reserve of at least 30% relative to the required driving force.

### 9.3.3 Service unit

For pneumatic controls a service unit shall be provided.

This service unit shall be equipped with an "electric switch-on valve", a "filter", a "pressure regulating valve", an "electric push-button switch" as well as a "pneumatic pressure build-up valve".



The electric push-button switch shall be set such that an error message is displayed when the pressure falls below the minimum acceptable pressure. Then, the machine must remain in error mode until the required pressure is restored and the error has been recorded manually. The machine must not continue with the process. Exceeding the maximum acceptable pressure shall be prevented by means of a pressure regulating valve in the service unit. The limits shall be set to 5.5 bar  $\pm$  1 bar as a standard.

Distributors, Ts and throttles shall be screwed to the machine components.

### 9.3.4 Z-cylinder strokes with depressurized machine

When the machine is depressurized, e.g. by opening the guard door, the descent of the cylinders must not present a hazard (risk assessment) or damage parts or fixtures.

All Z-cylinder strokes which descend or may lead to collision due to the depressurizing of the machine shall be secured against descent. For setting up the machine and/or trouble shooting manual overrides shall be used.

Use HGL valves with manual unlocking mechanism, supply via p, do not connect crossover.

### 9.3.5 Maintaining the grip force

Grippers which maintain the grip force shall be used if the parts may lose their position during pressure drop. Parts shall be removable from the gripper when the guard door is open.

No regulators must be installed in pneumatic grippers with strokes shorter than 10 mm. (a Pn stroke shorter than 10 mm cannot be regulated.)

### 9.3.6 Pressure regulating valve

Process relevant pressure regulating valves shall be lockable, as a rule.

As an alternative, the pressure may be controlled by the PLC via a pressure sensor. The specifications may only be changed in the password "Level 3".

## 9.4 Safety enclosure / cover panel

In order to reduce possible contamination of the parts / machine/ system, the manufacturing equipment shall be completely enclosed. The use of closed sections for the outer cover panel ("shell", the sections are open inwardly) shall be preferred. If open sections are used the notch shall be provided with a cover.

Cover panels and safety enclosures shall be designed such that the individual components are easily accessible from all sides.

Covers integrated in the machine shall be fastened such that they can be disassembled quickly and easily in case of maintenance and repair. The cabinet covers shall be entirely closed and should have a planar surface for reasons of easier cleaning. Gaps on the side are not permissible. For covering the machines/systems cover panels made from transparent plastic shall be used. The roof of the machine shall be made of translucent multi-wall sheets.

Doors and other covering parts above the table plate shall be made of "clear" and uncolored polycarbonate. Depending on the design of the machine, darkening may be required in case of laser welding machines for safety reasons or in case of image processing for blocking the light.

All openings below the table plate shall be closed with a suitable cover. For accessibility reasons, these shall be mounted with hinges, magnetic latches and handles at the required locations.

The signal lamp/column shall be attached to the safety enclosure such that it is well visible from the operator side and close to the control panel, if possible. The positioning height shall be agreed upon individually.

In case of processes involving photo sensors or image processing, the machines or processes shall be protected against extraneous light.

## 9.5 Supporting arm

In case of rotary indexing tables and machines (cabinets) having a width of more than 1 m, the control panel shall be mounted on a supporting arm.

For rotary indexing machines, the supporting arm shall be swivable about 360 degrees. The supporting arm shall be mounted in the center of the roof of the enclosure. The signal column shall be installed above the axis of rotation of the swivel arm. The height of the control panel is described in chapt. 7.

## 9.6 Illumination of the cabinets, workplace illumination

For troubleshooting, process monitoring and maintenance works the cabinets shall be equipped with lamps. The lamps to be used are listed in the Preferred Components equipment specification.

Illumination of the insert area shall be possible via a light switch.

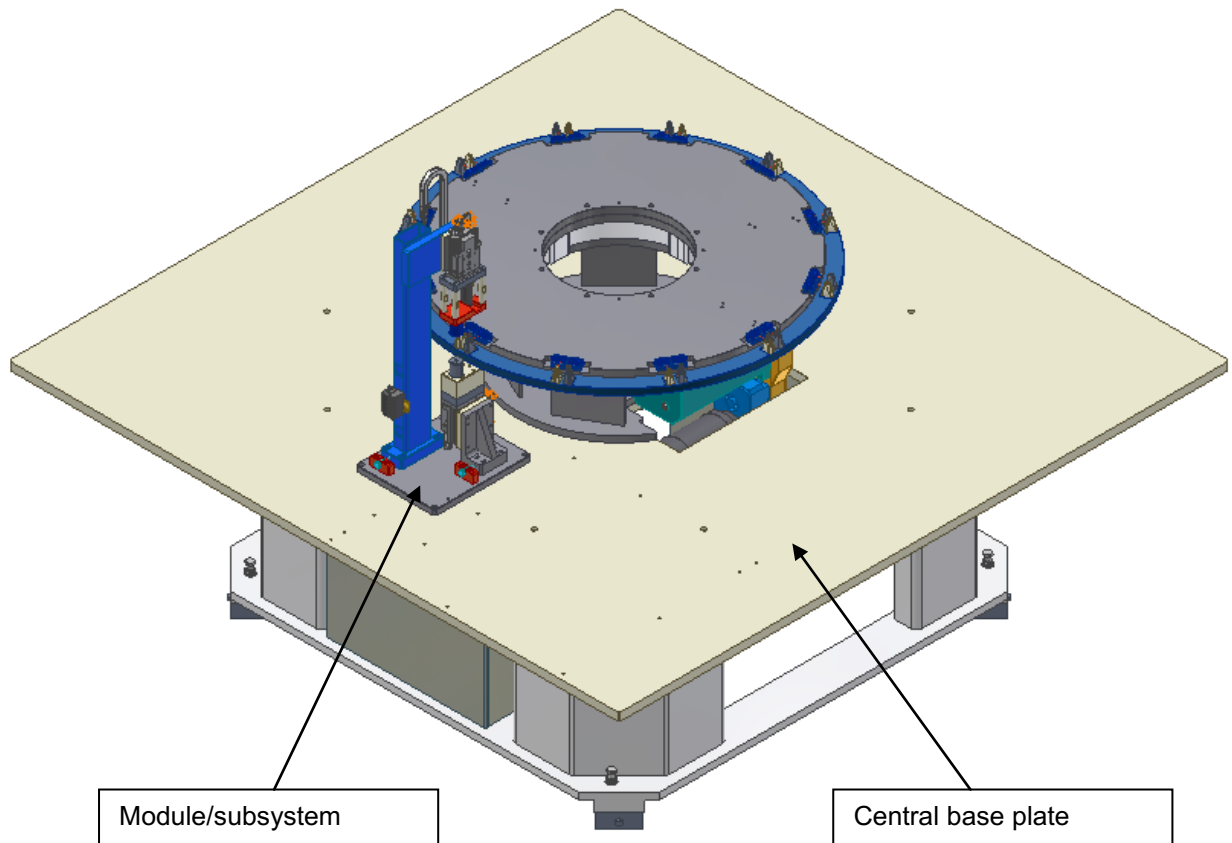
It must be possible to separately switch the machine illumination on and off for service purposes. In case of larger linked machines the machine illumination shall be controlled centrally.

Manual workplaces shall be well illuminated.

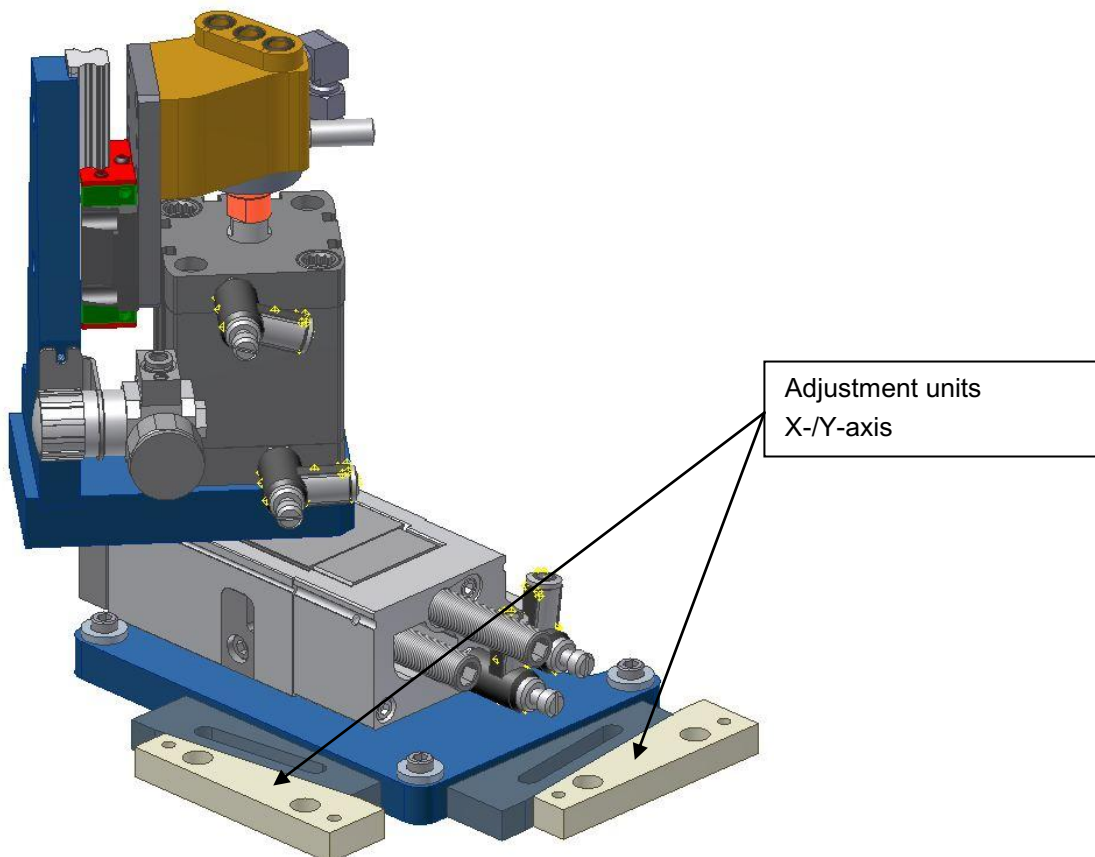
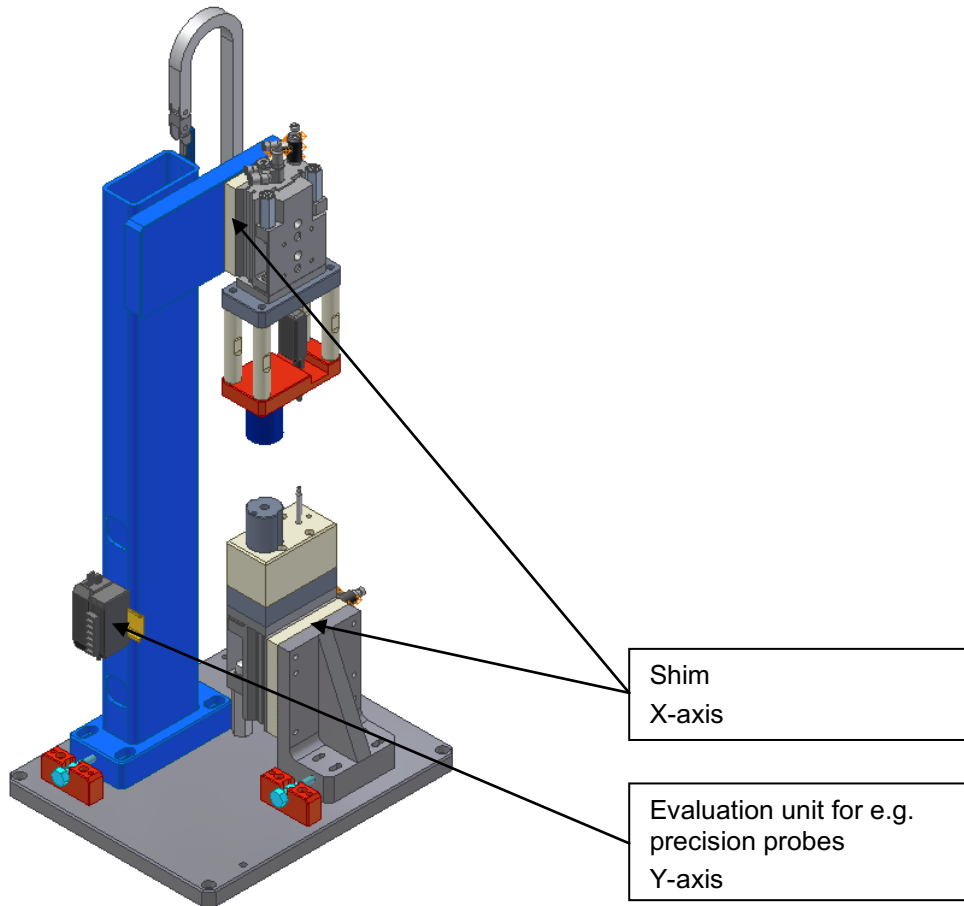
## 10 Modular structure of machines / systems

### 10.1 Machine / system structure

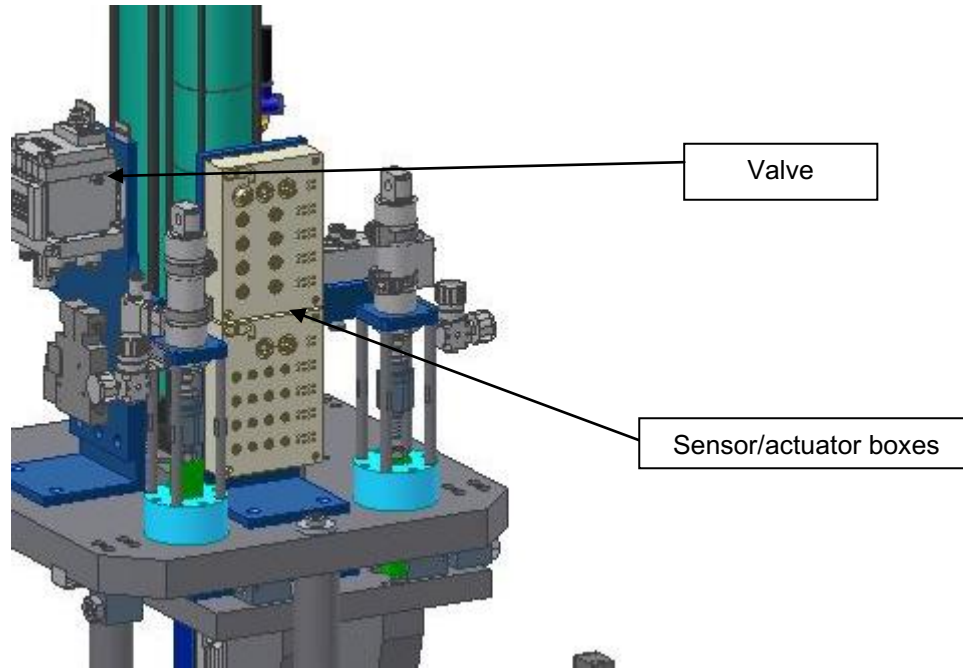
Modules / subsystems shall always be mounted on a "separate" base plate. During assembly, this base plate is fastened in a form and force closing fashion on the central base plate of the machine/system. The modules/subsystems shall be adjustable by means of adjustment bars. Pinning shall only be performed after acceptance by ETO.



If measuring and test cycles are performed on a module/subsystem, the evaluation units shall be installed on this same base plate, as possible.



In case of modules/subsystems having more than 6 pneumatic actuators, the valve terminals as well as the sensor/actuator boxes and maybe also the terminal boxes shall be installed on the base plate of the module/subsystem such that they are easily accessible.



## 10.2 Cross-beams and press frames

Cross-beams and press frames shall be designed to resist twice the load that is required for safety as regards rigidity and strength (e.g. twice the maximum actuator force). "Bending" of the system shall be reduced to a minimum.

Cross-beams and press frames shall be designed such that vibrations or shocks do not have any impact on the process.

As a rule, D frames shall be preferred to C frames.

## 10.3 Joining and force fitting processes

Joining and force fitting processes may be performed with or without force/stroke monitoring, see specifications sheet.

ETO defines the press force in the specifications sheet. The process shall be designed having a safety factor for the press force of at least 1.8.

In case of force/stroke monitored joining and force fitting processes, the pressure transmitters shall be arranged in the force axis between drive unit and tool. The pressure transmitter shall be positioned exactly at the tool. This prevents errors in the measuring values caused by transverse forces and mechanical elements (e.g. bearings, moving parts).

The use of common pneumatic cylinders for force/stroke monitored force-fitting of parts shall be evaluated thoroughly since an exact recording of the F/S characteristic curve is often difficult. The use of an hydraulic cushioning cylinder may be required. No clamping cylinders must be used for support during pressing and joining processes. The support shall be locked mechanically. In case of two-step joining processes (e.g. force-fitting and caulking), the first position shall be mechanically locked.

Wear debris possibly developing during force-fitting or shaping processes shall be removed by suction directly at the origin such that the wear debris is not carried over to subsequent processes.

## 10.4 Handling units

All handling units shall be designed to have a resistance allowance of at least 30% to be able to withstand increased stresses occurring during continuous operation (preferentially regarding speed, rigidity, precision).

Axes subject to gravitation (vertical axes, Z-axes) shall be secured against dropping when the machine is disconnected from power (e.g. EMERGENCY STOP / guard door open, etc.) in order to prevent hazards or damages to parts and fixtures. In this connection, securing the Z-axes shall also be provided for according to the risk assessment.

For all axes external stops shall be provided for stroke limitation in order to prevent damage of the fixture.

All cables and wires shall be inserted in drag chains, separated according to the media by using internal separators, and designed to have a strain relief.

For position control of handling units (from system axis to gripper bracket), fixed reference positions shall be provided.

### 10.4.1 Linear units

Linear units shall be equipped with adjustable fixed stops and dampers.

If a very high positioning accuracy is required (e.g. for force-fitting and joining processes), the linear units shall be equipped with external stop sleeves. In this connection, special attention shall be paid to ensure that the stop sleeve is positioned exactly central on the force axis. If this is not possible, fixed stops shall be installed on both sides.

The stop sleeves shall be labeled with the adjustment measurements after adjustment has been performed.

An additional set of unadjusted stop sleeves is included in the scope of supply and shall be labeled.

In case of motor-driven axes (servo axes) a collision protection shall be provided in the direction of joining for joining and inserting processes. This protection may be realized by means of pneumatic slides. The pneumatic feed shall be adjusted via a separate pressure regulating valve. As an alternative, a mechanical solution with predetermined breaking points is also possible.

#### 10.4.2 Lift/swivel units

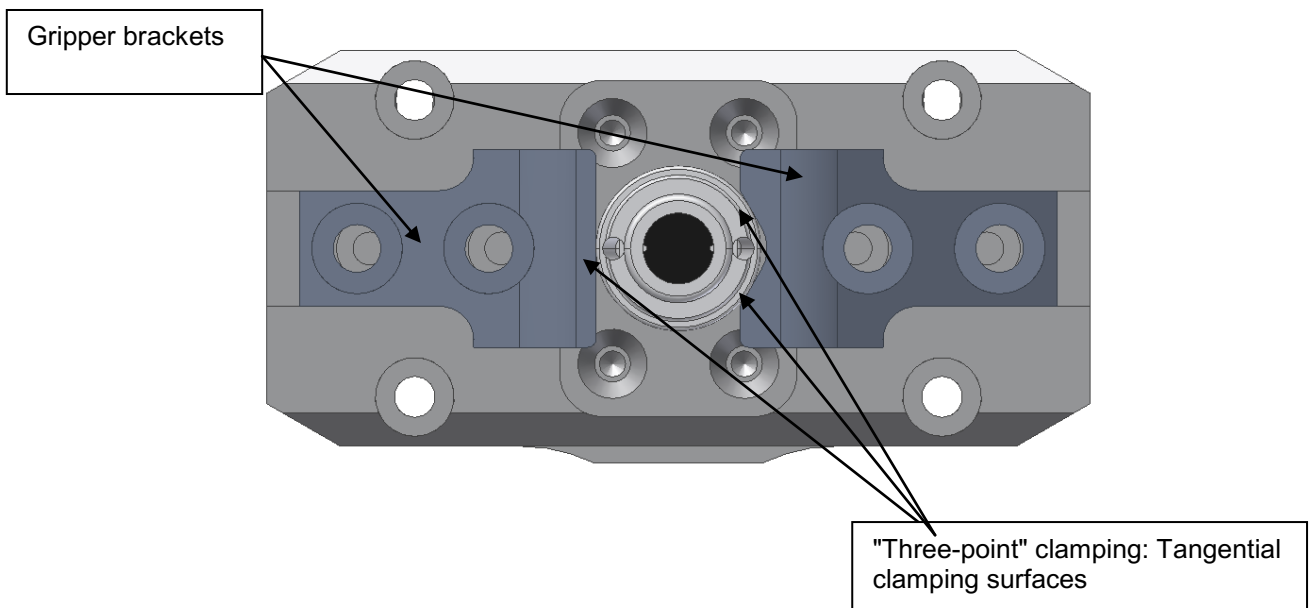
The use of rotary modules is generally not permitted for machines and facilities. Exceptions are only permissible after consultation of ETO. For machines and facilities it shall be thoroughly examined whether the use of a rotary module is reasonable regarding position accuracy.

For all rotary modules (having a swivel radius of more than 50 mm), adjustable end stops arranged externally and if possible at the outermost edge of the radius shall be installed. The axial force acting on the shock absorbers shall be observed,

#### 10.4.3 Gripper technology

When selecting the gripper technology, the use of angular grippers shall be avoided.

In case of gripper systems for "round" parts, "three-point" clamping shall be provided.



The grippers shall be designed such that they do not cause any damage to the part. The edges shall be softened by radii. The material of the grippers shall be selected according to the field of application. Grippers made of hardened steel (58 HRC  $\pm 3$ ) having a blasted surface shall preferably be used. Vulcanized grippers are not acceptable.

In order to prevent pressure marks, pneumatic grippers shall be equipped with an adjustable pressure regulation, if applicable.

Note: As overload protection, the fastening bolts for the gripper brackets may be designed having predetermined breaking points.

### 10.5 Rotary indexing tables

If rotary indexing tables are used, the manufacturer specifications regarding indexing accuracy shall be observed. The tolerance chains of the rotary table supports shall be calculated in consideration of the product tolerances. Here, a safety tolerance of 20% regarding positioning accuracy shall be ensured.

For controlling the rotary table positions additional fixtures shall be manufactured and included in the shipment which allow for the measurement or gauging of the individual rotary table supports in the processing positions of the machine. (1. home position of rotary indexing table, 2. alignment of station relative to rotary indexing table)

The rotary table supports shall be labeled.

### 10.6 Feeders and attachments

Classic feeders are e.g. bunkers, feeder bowls, feed rails. Attachments are e.g. palletizers.

Feeders and attachments shall, if feasible as regards installation size, be installed on the "central" base plate. If a common assembly is not possible, these shall be connected to the base frame in a force and form closing manner.

It shall be possible to fill and empty palletizers, graders and bunkers outside of the protection equipment in order to prevent production interruptions and/or machine idle time.

The capacity at the removal position shall be at least 1.5 times the required capacity for the machine clock rate.

Feed rails shall be equipped with a buffer which switches the bowl on and off. (stock between min./max. approx. 10-20 parts)

Feeder bowls shall be equipped with a filling level control, which switches the bunker on and off. If no parts bunker is provided, a signal is sent.

Parts bunkers shall be equipped with a filling level control. When the minimum filling level is reached, a signal is sent.

Feeder bowls shall be equipped with a cover, hinges and a stop.

A noise-protection shall be provided for feeders. The maximum noise level of 70dB(A) must not be exceeded.

The filling height for loading the feeder with single parts must not exceed 1.20 meters (floor to top edge of feeder bowl). In case of attachments the removal height of the pallet is 1.20 meter max.

No parts must remain on the interface between feeder bowl and feed rail.

Feeder bowls shall be made of "stainless" steel having a black plastic coating or be made entirely of plastic (polyamide).

Feeder bowls as well as feed rails shall be provided with bores for dirt removal. The dirt shall be transferred to collecting trays ("RED" color).

The parts stock in the feeder bowl shall be kept as low as possible for sensitive parts (scratches, dents, other damages).

Bunker systems shall be made of "stainless" steel. The drive units of the conveyor belts shall be located facing downward.

The vibration frequency shall be adjustable and lockable.

The complete feeding system shall be controlled via the PLC of the entire machine (controller inhibit). The machine parameters for switching the feeding system on and off can be adjusted in the PLC.

All connecting wires shall be plug-in cables. Generally, all plug-in sensors shall be designed as PNP sensors.

The entire wiring shall be installed on a sensor/actuator box (SAB box). For cylinders and grippers, if applicable, a valve terminal shall be provided.

The control units shall be equipped with sockets for the connection to the vibration conveyors. The vibration conveyors shall be equipped with suitable mating plugs.

The switch-on current must not exceed  $I_{max}$ . 20 A. Moreover, the control devices shall ensure a soft start and soft stop and compensate possible voltage fluctuations.

The machine autonomy of feeders and attachments is described in the specifications sheet.

For troubleshooting and cleaning purposes, feed rails and covers shall be designed such that they can be "removed quickly". Removable parts shall be positioned exactly using positioning aids.

In case of retooling processes, all interchangeable components, feeder bowls, bunker systems and/or feed rails shall be replaceable within a maximum of 5 minutes. All interchangeable components shall allow fastening without alignment, i.e. just by bolts and positioning pins.

The feeder bowls and feed rails shall be equipped with a rapid-emptying unit.

## 10.7 Cable chains/drag chains, plug connectors

All cables, wires and hoses shall be inserted in drag chains separated according to the media by using internal separators and designed to have a strain relief. Outside of the drag chain, the cables, wires and hoses shall be designed as plug-in devices (no plug connections acceptable in the drag chain).

The drag chain may be filled to a maximum of 70%. The cables, wires and hoses must not lie crosswise or be twisted in the drag chain.

The cable conduit shall be designed to have cable ducts and clips. All light conductors and sensor cables shall be protected against bending and be equipped with a cover.

## 10.8 Laser barriers

Laser barriers shall be labeled with the identification and warning signs according to the specifications (class, wavelength, etc.). Only lasers of safety class 1 may be used. If other lasers are used, this shall be justified and agreed upon with the ETO security expert for laser safety.

## 10.9 Measuring and test equipment

The design of the measuring and test equipment shall be agreed upon with the project manager and the ETO technical departments.

For linear measurement (dimensions, stroke, etc.) tactile measuring systems shall be preferably used. Prior to the use of optical systems for linear measurement, the ETO project team and technical departments shall be consulted.

## 10.10 Exhaust systems

For any process tending to produce "dirt", a suitable cleaning system shall be used.

In case of systems having workpiece carriers, a separate cleaning station shall be provided such that only "clean" workpiece carriers are being used.

"Blowing only" is not permitted at ETO. When compressed air is used, suction shall be provided at the same time (cross jet process). For energy saving reasons suction devices according to the Venturi effect shall not be used. During idle time of the machines, the suction device shall be switched off, and/or the openings to the ETO exhaust system shall be closed automatically.

## 10.11 Other components

Spring packs: For service reasons, system springs shall principally be preferred over disk spring packs.

## 10.12 Process relevant parts

### 10.12.1 Setting parts

For all processes, which require exact set-up, precise hardened setting parts shall be manufactured and included in the shipment. Suitable and labeled storage space shall be provided at the machine.

The design of the setting parts shall be agreed upon with ETO. A drawing of the setting parts shall be part of the shipment of the machine. The drawing shall exactly specify purpose and application of the setting part.

### 10.12.2 Retooling and interchangeable parts

Retooling and interchangeable parts are used when type changes are performed. Entire tools may also be changed. When retooling parts or tools are changed, the media connections may also be affected.

Retooling and interchangeable parts shall be fastened in a form closing manner. Observe Poka-yoke! The parts shall be easily accessible and easy to assemble.

Pneumatic and electrical connectors shall have a common plug, if possible.

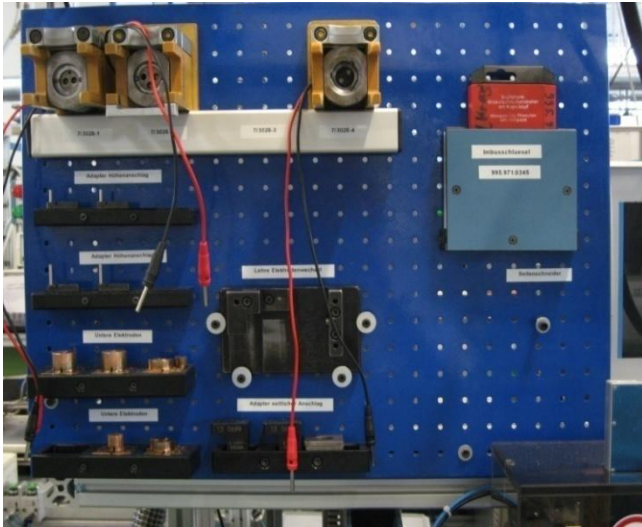
Retooling and interchangeable parts shall be labeled permanently (e.g. by engraving or laser). Additionally, all retooling and interchangeable parts shall be marked according to the various types using colors and the markings be easily discernible. (The marking is specified in the specifications sheet.)

Retooling should be possible without any tools (e.g. quick release). If this is not feasible, the required tool should be a "common" one (e.g. having a hexagon socket head). The tool shall be included in the shipment of the machine. It shall be ensured that only one tool size (width across flats) is required for retooling, if possible.

Retooling and interchangeable parts shall be polled in the machine. Entire tool sets are distinguished via a code in the plug.

For all processes it shall be ensured mechanically or by using controls that the interchangeable parts are assigned to the defined product type. When retooling parts are mixed up, this must not represent any hazard to man and machine.

Storage of the retooling and interchangeable parts as well as the tools required for retooling shall be ordered and storage space labeled properly at the machine. Examples:



### 10.12.3 Spare parts and wearing parts

Spare parts and wearing parts shall be provided from standard parts, as possible. Spare parts and wearing parts shall be selected and/or designed such that the parts may be ordered from several companies / suppliers, as possible.

Wearing parts shall be designed such that they can be reworked. Rework dimensions (standard rework dimensions as well as dimensions after which rework is no longer possible) shall be indicated on the drawing.

At least one additional set of wearing parts shall be included in the shipment of the machine.

### 10.12.4 Reference parts

Reference parts serve to examine the used process monitoring method. The scope of supply is described in the specifications sheet.

Reference parts shall be wear resistant. Reference parts shall be clearly labeled and identified by color (green: OK; red: NOK.). A labeled storage space shall be provided for the reference parts. If required in the specifications sheet, the reference parts shall be encoded at the storage space.

It shall be ensured that the reference parts can be clearly distinguished from the product. "Further processing" must not be possible.

## 11 Calibration

Suitable holders shall be manufactured for the test equipment (e.g. load cells), the processes of which are subject to regular calibration by ETO.

Suitable media connections shall be provided at every measuring point as close as possible to the specimen.

The calibration is generally performed manually. If this is not possible, suitable special programs shall be established.

The calibration process shall be described in detail in the operating manual.

## 12 Cleanliness requirements

The cleanliness requirements for facilities and machines are described in the specifications sheet.

In assembly equipment, various types of contamination may occur:

particle development caused by the joining process itself, e.g. particles are produced at the threads during tightening of screws or when inserting screwdriver bits.

particle development of the equipment, e.g. caused by mechanical wear at linear drives, electric motors or feeding and handling equipment.

particle introduction into the process area by e.g. the feeding equipment (contaminated conveyor belt or workpiece carrier), contaminated outer surfaces (of parts, tools or containers) the personnel (carryover by their hands, ...) or airborne/falling particles from the surroundings.

### 12.1 General design principles

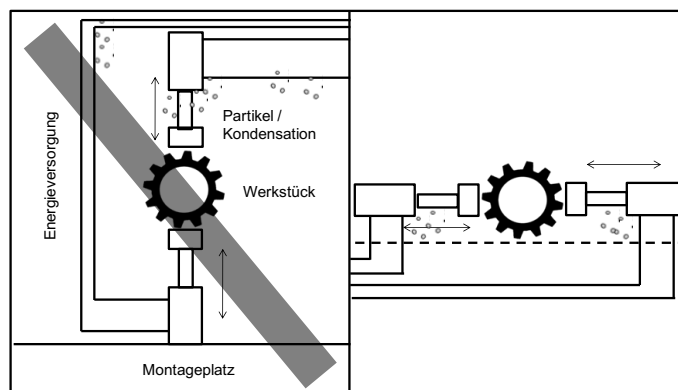
Minimal usage of horizontal surfaces. By means of inclined areas (e.g. covers) increased accumulation of contaminants or storage of objects can be prevented.

Designing smooth surfaces without any recesses or gaps.

Avoid sharp edges. Soften angles and edges, as possible.

Provide easy accessibility for cleaning.

Do not place potential particle sources above sensitive surfaces.



Provide packaging and/or exhaust systems at the particle source.

If applicable, eliminate particle source from immediate process area by means of e.g. extensions.

Use of local clean air technology for removing small airborne particles.

From an environmental perspective Venturi exhaust systems shall be avoided and electric industrial exhaust systems shall be used instead. During idle time of the machine, the electric exhaust systems shall be switched off after a certain time which can be adjusted via the PLC. This shall be observed when selecting the exhaust system.

Note: When an exhaust system or clean air flow is used, possible detrimental effects on the temperature constancy shall be considered (e.g. when curing adhesive).

### 12.2 Materials and surfaces

For minimizing accumulation and release of particles, the following properties should be considered when selecting the materials:

Wear resistance (painted surfaces should be avoided as possible; wear causing release of paint particles)

Surface roughness / porosity

Chemical resistance against process fluids as well as cleaning agents

Electric conductivity / electrostatics <sup>1)</sup>

Magnetism<sup>1)</sup>

<sup>1)</sup> May cause stronger adhesion to the surface.

Note: Special steel is preferred in cleanliness technology.

## 12.3 Machine components

### 12.3.1 Basic structure

Open, unobstructed design of horizontal surfaces (e.g. burr-free perforated sheet metal: particles fall into a tray or on the floor where they can be removed regularly.)

Avoid protruding bolt tips and heads for easier cleaning.

Avoid through holes (e.g. fastening a bench from below using blind holes.)

Application of fittings and hinges at the outer side of the machine or below critical areas (dirt traps and particle source).

Omission or removal of components not/no longer essentially required for the process. As a rule, only objects required for the process shall be in the assembly equipment.

Provide "standardized" interfaces for flexibly connecting hand-held vacuum cleaners.

Fasten floor-side enclosure flush with bottom part or such that easy access is provided for cleaning below the assembly equipment.

Exhaust air of e.g. fans, electric motors or pneumatic cylinders and valves should not be directed into the inside of the equipment, or not directly on sensitive surfaces.

Supply lines (cables, tubes, etc.) shall be guided outside of the immediate process area, as possible. Supply lines must not be installed on the floor.

Piping and machine components at which condensation may occur shall be provided with insulation.

### 12.3.2 Enclosures

Enclosures may be required for safety reasons only. Enclosures also protect machines from airborne particles, and prevent particles developed during the process from being released into the surroundings.

Enclosures shall be designed such that contaminants cannot accumulate.

Flaps, covers and doors of the enclosure shall be attached such that contaminants do not fall into the machine when said flaps, covers and doors are opened and/or removed.

Ports for heat removal shall not be provided in the cover, but e.g. at the side panels of the top part of the machine. As an alternative: Protect ports from particles falling in the ports by using cover plates.

Grate elements are not permitted as enclosures at ETO.

Note: By means of enclosure a local area can be provided, the cleanliness level of which deliberately deviates from that of the surrounding, e.g. enclosed blowing station. For further notes, see chapt. 9.4.

### 12.3.3 Manual workplaces

By means of a specific design of the workplace as well as the procedures, cleanliness related errors by the worker shall be avoided.

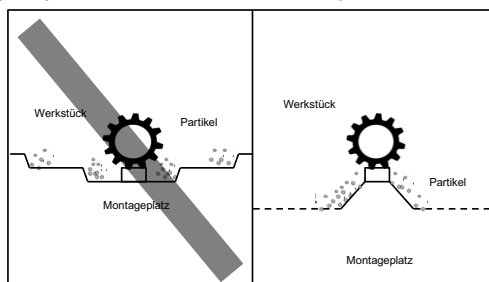
The material supply at the workplace shall be provided from the rear side or side of the workplace, as possible.

Provide generous illumination, if possible diffused glare-free light without shadow casting.

Ensure that the worker does not need to reach over the product when accessing parts and tools.

Provide designated storage space for tools and equipment. Tools and assembly equipment shall preferably be attached hanging vertically.

Storage space as well as holders for tools and parts shall be designed such that they have the smallest possible contact surface. By means of a design open towards the bottom, particle accumulation can be minimized.



Do not install storage spaces, containers or picking boxes directly above the work area. (This ensures that the operator does not have to reach over the product regularly.)

Used enclosed shelves in order to prevent contaminants from falling on the lower level.

Provide small parts in closed dispensers if possible (not as loose material).

Do not install picking boxes, containers and dispensers directly below the work area but shifted to one side.

Install sieve bottoms in the picking boxes. (Particles cannot accumulate at the bottom)

Use closed liquid dispensers. (Only the amount of liquid is supplied that is needed.)

Cushion hard contact surfaces to protect workpieces and surfaces by e.g. rubber mats under special steel plates.

Do not use soft work surfaces such as wood or plastic. Ribbed anti-slip mats or damping mats must not be used.

#### **12.3.4 Media supply**

The supply systems should be installed in intermediate ceilings and walls, if possible, by e.g. using cable ducts.

Supply systems running through the process area should have as little horizontal surface as possible and be installed vertically, if possible.

Exhaust air from e.g. pneumatic units shall be guided outside of the process area through hoses; filters and exhaust silencers may be installed, if applicable.

Hoses and cables (e.g. compressed air ducts) of movable elements shall be fixed to prevent rubbing. Use of cable drag chains.

#### **12.3.5 Auxiliary material for performing the processes**

Process-integrated filtration of the relevant fluid.

Keeping the exposed fluid clean.

Keeping the auxiliary material and tools for applying the fluid clean.

Perform oiling processes in enclosures and/or use exhaust systems.

Use silicone brushes or dispensing devices for oiling instead of hair brushes (hairs could fall off and stick to the product).

#### **12.3.6 Transport systems, handling systems, feeding and separation**

When selecting drive systems, the amount of particle generated by these systems should be taken into account.

Drive units, linear axes, cylinders, cable chains and other movable equipment shall be installed below the critical areas, as possible.

Avoid having reversal points (e.g. of belts) above the product.

In case of systems for separating and feeding small parts (e.g. vibration spiral conveyor) suction devices for the single part shall be provided. As an alternative, openings in the feed rails shall be provided, through which loose particles fall into a collecting tray below.

#### **12.3.7 Workpiece carriers, workpiece holders, tools, grippers**

Part transfer systems shall be designed such that workpiece carriers are lifted from the belt when the machine is stopped. As an alternative, the belt shall be stopped (wear debris caused by the friction between belt and workpiece and/or workpiece carrier is avoided).

The contact surface between workpiece carrier and product should be as small as possible (Please note: Possible high point loads at the product).

Grippers and/or workpiece holders shall have radiuses instead of chamfers.

Integrated bore in the tool for exhaust purposes (e.g. for bending punches).

Especially for manual assembly, insertion aids, cover plates, templates or centering aids shall be provided and used. (Damages on interfering contours are avoided)

## 12.4 Assembly-integrated cleaning

Purpose of assembly-integrated cleaning is to remove particles immediately after they have been generated. Assembly-integrated cleaning is used for direct cleaning of parts and/or assemblies. Cleaning steps may be integrated into an assembly line, the aim of which is continuous contamination control of machine components, such as cleaning of workpiece carriers, conveyor belts or grippers.

Simple solutions shall be preferred, characterized by the following:

Suitable cleaning efficiency (process reliability)

Use at the location where the particles are generated, if possible without having to remove the object to be cleaned from the given workflow and/or procedure.

If possible no additional handling, such as e.g. change of position or cushioning.

If possible no increase of clock rate

No contamination of the parts to be cleaned with residual products from cleaning agents

If possible (simple) automation

The effectiveness of a cleaning step to be established shall be ensured by practical tests.

## 13 Identification

### 13.1 Identification plate

Every equipment and/or automatic machine shall be provided with an identification plate. The plate shall include the following specifications (minimum specifications according to EC Machine Directive):

Company name and complete address of manufacturer and proxy, if applicable

Equipment designation

CE identification

Line or type designation

Serial number, if applicable

Year of operation acceptance

Connection data (frequency, voltage, current, compressed air)

Weight

The identification plate shall be attached at an easily accessible location. (Preferably at the main switch)

### 13.2 Cabinet numbering of linked lines

In case of assembly lines, the cabinet numbering starts with 105. All other cabinets are numbered in intervals of 5, e.g. cabinet 105-110-115. If assembly machines for further process steps are installed separately, the numbering is continued in intervals of 100, e.g. 205-201 as well as 305-310-315.

Plates (size 210mm x 100mm x 4mm) for cabinet numbering are provided by ETO.

### 13.3 Equipment numbering

Plates for equipment numbering are provided by ETO.

### 13.4 Reference designations

Every equipment, cable, electrical enclosure, terminal box, terminal block, plug connection etc. shall be provided with reference designators. These shall comply with the circuit diagrams and be included in the parts lists. This shall particularly be ensured for the supply of attachments or machine extensions for existing machines.

All cable connections (including sensor systems and valves) between switchboard/distribution board and machine/module shall be labeled on both sides. This is to allow for the maintenance personnel to easily identify cable connections. The same applies to the use of plug connections.

Conventional control, display and signal units shall be identified with white Resopal or aluminum signs/pad printing and labeled with black letters. The signs may be glued or screwed to the units using non-corrosive bolts. When control panels are used, the keyboard overlays supplied by the manufacturer shall be used. Handwritten labels must not be used. Machine stations, service switches and frequency converters shall be visible and clearly identified. The texts shall be agreed upon with the responsible technical department at ETO.

The reference designation shall be visible from outside, if possible.

The reference designator for pneumatic movements is derived from the pneumatic plan. The sensors assigned to a pneumatic movement are transferred from the pneumatic plan.

#### 13.4.1 Structure of reference designators

1	B	13	.	01
Location	Identifier	Number	Delimiter	Function

Example: 2B03.02 → This designation means:  
 Location: 2 (station)  
 Type: B (sensor)  
 Number: 03 (valve/cylinder)  
 Delimiter: .  
 Function: 02 (operate condition)

**Location**

The location refers to the station to which the reference designator is assigned.

Location	Use for
0	Higher-level machine functions (main air, main switch, emergency stop, guard door, etc.)
1 - X	Station 1 - X

Type, identifier (in the style of DIN EN 61346-2):

Designators	Use for
B	Sensor, precision probe, position switch, thermal overload relay, light curtain
F	Fuses
K	Auxiliary relay, relay, CPU, control valve, binary module, analogue module
M	Motor, cylinder, control valve
P	Signal lamp, horn, TP, OP
Q	Main contactor, motor starter, main switch
S	Mechanical switch (electric/pneumatic)
T	Power supply
U	Electrical enclosure, housing
W	Cable
X	Terminal block, socket

**Number**

If the equipment is assigned to a pneumatic movement, the number is equivalent to the number of the valve.  
 In case of electrical equipment the number is a continuous number.

**Delimiter:**

The delimiter „.“ separates the number from the function. If classification within the number is required, the point is replaced by lowercase letters.

Example: 1B01a01: Cylinder 1a  
 1B01b01: Cylinder 1b

## Function

Function denotes the function of the relevant device according to the following table:

Function	Use for
01	GST Grundstellung (start position)
02	AST Arbeitsstellung (work position)
03	MST 1 Mittelstellung 1 (middle position 1)
04	MST 2 Mittelstellung 2 (middle position 1)
05	Analogue signal
06 - 09	Not yet defined
10	PLC, CPU
11	Control panel (not PLC)
12	Valve terminal
13	Others, decentral I/O
14	Field bus (e.g. profibus)
15 - 19	Not yet defined
20	Equipment is part of emergency stop circuit
21	Equipment is part of guard door circuit
22	Equipment is part of the operator intervention protective circuit
23 - 29	Not yet defined
30	Pneumatic drive unit
31	Electric drive unit
32	Hydraulic drive unit
33 - 89	Not yet defined
90	Equipment connected to 400V AC potential
91	Equipment connected to 230V AC potential
92	Equipment connected to 24V DC potential
93	Equipment with special voltage supply
94 - 99	Not yet defined

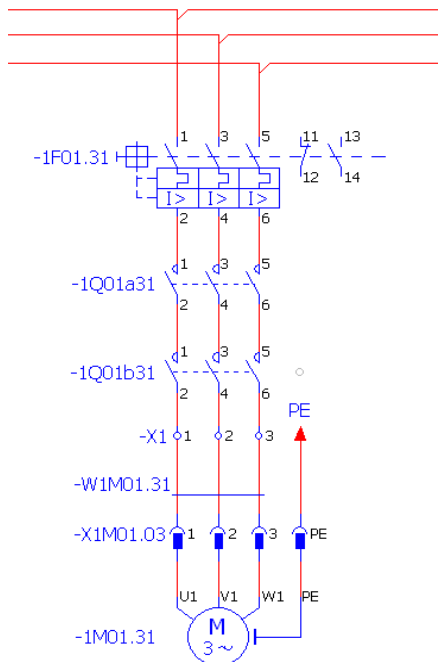
### 13.4.2 Cable designation/plug connector designation

The designation of cables and plug connectors is based on the connected equipment and having the additional designator W for cable and X for plug. Bus lines are given a "B" additionally.

Example: See chapter 13.4.1

### 13.4.3 Linked equipment

Linked equipment are components which succeed one after the other immediately. Based on the final unit, these are given the same designators as regard function and number.



Reference designator	Description
-1M01.31	Main equipment electric motor
-1Q01a31	Main contactor 1 for motor -M01.31
-1Q01b31	Main contactor 2 for motor -M01.31
-1F01.31	Motor contactor for motor -M01.31
-W1M01.31	Connecting cable for motor -M01.31
-W1M01.31B	Bus cable for motor -M01.31
-X1M01.31	Plug for motor -M01.31

### 13.4.4 Standard reference designation

The following reference designation shall be used at ETO:

	Reference designation	Description
Machine supply	-0Q01.90	Main switch (400V)
	-0Q01.02	Main air valve
	-0B01.02	Pressure switch
Emergency stop	-0K01.20	Safety relay for emergency stop, safety PLC
	-0S01.20	Push button switch for emergency stop 1
	-0S0x.20	Push button switch for emergency stop x
Guard door	-0K01.21	Safety relay for guard door
	-0S01.21	Guard door switch 1
	-0S0x.21	Guard door switch x
Circuit of operator intervention	-0K01.22	Safety relay circuit of operator intervention
	-0S01.22	Guard door switch of operator intervention 1
	-0S0x.22	Guard door switch of operator intervention x
Tester / signal lamp	-xS01.92/-xP01.92	Station x illuminated push button yellow "control on"
	-xS02.92/-xP02.92	Station x illuminated push button green "start"
PLC	-0K01.10	PLC
	-0K0x.10	Unit x to PLC
HMI	-0P01.10	TP, OP to PLC
Valve terminal 1	-xQ01.12	Station x pneumatic system valve terminal 1
Axis motor	-xM01.31	Station x electric motor 1

## 13.5 Color codes

### 13.5.1 Color code of pneumatic hoses

The following color codes shall be used at ETO:

Color	Description
black	Air ducts for work position
blue	air ducts for start position
red or yellow	air ducts for vacuum
silver gray	air ducts for other functions
green	use prohibited (used for cooling water)

On valve terminals, the output for the work position shall always be at 2 or 12 and the output for the start position shall always be at 4 or 14.

### Color codes of other hoses

Color	Description
green	Cooling water