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1 Purpose and scope

The present "Technical Procurement Specification for production equipment, subsection Mechanical Requirements" defines the basic requirements within its scope for operating equipment described in further detail in process and project-specific requirement specifications. The requirements in the version in effect on the date of ordering must be implemented for the order as a mandatory requirement. This document is updated at irregular intervals to reflect the state of the art. This document is part of the overall description on the technical implementation of production equipment and binding in combination with the superordinate documents and referenced standards.

2 Application at NIDEC production sites

This requirement specification is valid for all European Nidec production plants of the business unit Automotive Motors Electronic Controls (AMEC).

This document is the standard document for all Nidec production applications, and not just for a single project. Additional documents describe the respective production step and complete the requirements.

Production describes the workflow from the start in individual part production, includes surface treatment of the individual parts, the assembly of modules and end products, and individual part testing through to final testing. This document provides a common basis for operating equipment; the additional documents describe the specific versions of the operating equipment and the project-specific requirements.

3 Confidentially classsification

The confidentiality classification for this Nidec standard requirement specification is "public".

4 Machine layout

4.1 Module structure

Machines and equipment are considered to be modules capable of processing various products and components when fitted with process engineering project-specific equipment and interlinked. This applies to, e.g.:

- Injection molding systems that are equipped with injection units and molds
- Surface treatment plants that are fitted with painting systems and process mounts
- Assembly equipment that is fitted with jigs and process technology
- Process engineering systems that perform project-specific machining
- Test systems that are equipped with jigs and specific metrology
- And others …

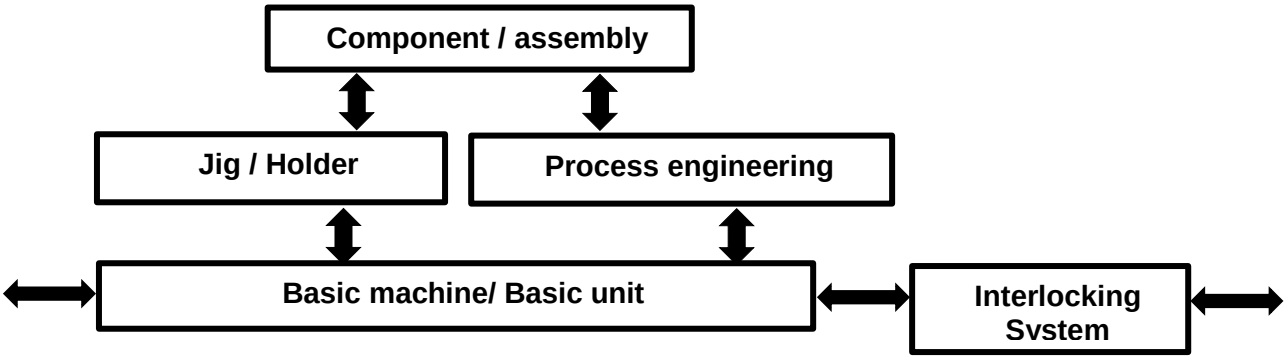
By standardizing the interfaces, the basic parts of the process become reusable and specific operating equipment interchangeable between production and factories. This applies to:

- Mechanical interfaces
- Supply equipment (cooling, ventilation, etc.), media supply (gases, paints, etc.)
- Control technology/program technology/network interfaces
- Process interfaces

The standard requirement specifications for application modules describe the basic machines, process units and chains with their respective interfaces. These are processed centrally by the Standardization Department.

The project-specific requirement specification includes the project description (project details, product, work stages, processes, and parameters) and references the existing standards for various assembly and process steps as well as this basic standard.

This modular system continuously adapts to the innovative Nidec product portfolio and provides the appropriate extension options.



4.2 Basic mechanical structure

The lifetime of the machines must be designed for at least 8 years (at least 3 years for driving tools). The assembly stations must always be designed such that various, project-specific tools, holders or workpiece carriers can be accommodated and can be processed by the setup. Up to 10 interchangeable holders must be provided for the electrical and mechanical design.

4.2.1 Design guidelines

- Work content that can only be performed with mechanization as a qualified process must be generally designed as automated production.
- The handling of design parts and parts with sensitive surfaces is typically performed using a system that removes the need for direct handling by staff.
- As an alternative, the supplier must elaborate partial or full automation solutions at appropriate points and present these in the concept release. These alternatives can deliberately avoid the specified automation solution.
- For "areas of interest," a gradual expansion of the automation must be suggested, and provided for as per the Nidec specification.
- The supplier must adhere to the cycle times/capacities cited in the process-specific requirement specification, also given the typical fluctuations in production processes.

4.2.2 General requirements

The basic structure of the production unit must be designed as a self-supporting system, preferably with a minimal number of machine feet. The required basic material must be selected as a function of the load (steel or aluminum). The fatigue limit must be verified by means of FEM computations for critical basic structures.

- Measurement, adjustment and testing systems must be equipped with steel frames as a general rule.
- Aluminum base frames are only permitted up to a size where they can be safely transported.

- Robots are either anchored directly on the shop floor (floor anchoring) or on steel brackets directly connected to the floor.
- The machine must comply with the outer dimensions specified in the technical documentation. Protruding components must be identified and dimensioned in the drawings.
- The design must take into consideration the maximum possible transport dimensions and weights for trucks and containerized shipping.
- A free space with a height of ≥ 120 mm, depth of ≥ 150mm must be provided on the operator sides as the employees' footwell.
- The machine feet allow height adjustment up to 30 mm across the entire footprint of the cell. Damage to the flooring must be avoided when moving the machine on the shop floor.
- Larger systems or modules must be provided with attachment points for lifting equipment/means of transport.
- A cell with a footprint < 2 m^2 floor must be designed to be stable without floor anchoring; it must be possible to retrofit floor anchoring at a later stage.
- Identical components without variations must be used within one system.
- Each piece of equipment must be provided with the appropriate workplace lighting (see list of preferred components).
- All surfaces must be protected as a function of the loads they are exposed to.
- Table supports, jig plates, etc. must be prepared for regular and complete wet cleaning (no steps, cable routing, screw heads, different levels, etc.).
- All moving parts whose wear can be reduced by lubrication must be provided with lubrication points.
- Adjustable holders must be designed to support guided adjustment.
- Exposed operating equipment components must be protected against damage and unintentional adjustment (e.g., pneumatic and electric connections, scanners, cylinders, sensors, etc.).
- Supply components below a machine top are accessible from the Operator side or the rear side. Arrangements in the side area are not permitted (obstructed by next work step on the assembly line).
- Ensure that design and structure are service-friendly. It must be possible to replace wear parts easily and without adjustments to the machine.
- If threads exist in aluminum or plastic components into which bolts are screwed during setup or maintenance work, a wear-reducing thread insert must be used (e.g., HeliCoil).

4.2.3 Material management

- The appropriate input and output options for the planned material throughputs must be provided at the interfaces between Logistics and Production.
  - Provisioning areas for the supply containers on the supply and output sides
  - Ergonomic individual provisioning of containers
  - Movement areas for trolleys
- NOK parts must generally be removed/discharged from the operating equipment via separate outputs, or only after acknowledgment by an employee.
- The production systems are capable of gradual loading at system start-up and can be completely emptied for setup work/emptying.

4.2.4 Layout/Logistics

- Production layouts must be agreed upon between the supplier and Nidec in the course of the design release; they must be released by Nidec. This includes:
- Overall dimensions of the production area (with supply routes, building facilities, supply interfaces, shop floor lighting, etc.)

- Logistics systems with transport routes, storage areas, opened containers, etc.
- Temporary storage areas for alternating holders and change-over material
- Organization areas for sample material, posting workplaces, rework
- Accessibility for change-over, repairs and maintenance must be available, generally with a tool trolley in sufficient proximity to the operating equipment.
- Main access routes and logistics areas can be cleaned using wet cleaning machines.
- High risk areas in the layout must be marked so that Nidec can provide appropriate bumper guards with floor anchoring.

4.2.4.1 Specific requirements for individual part production (prefabrication)

- The layout (tool handling, material handling, Operator access, etc.) and level of automation are driven by the requirement to implement the process in an optimal way
- Multiple machine operation is enabled by the clarity of the layout
- Crane runway areas cover the necessary operating points (change-over, preheating/precooling, installation, depositing, screw change) without interfering with the other functional areas. Main logistics routes must not be covered by crane runways.
- The crane can work around automation areas
- A provisioning workspace for preheating a typical injection mold must be planned for on the system
- The pellet logistics must be clearly separated from the individual part logistics
- Material trolleys for finished parts can be moved by hand in the logistics area with sufficient room for maneuvering
- Docked material transport systems connect the system to the processing production areas depending on the operating condition.

4.2.4.2 Specific requirements for finish technology and interconnecting systems

- Robot areas and storage equipment fully use the available building heights where possible
- Interconnecting systems remain within reach of the operator without the need to use ladders or platforms. Exceptions include crossings on transport routes (observe min. prescribed clearance heights)
- A direct connection to individual part manufacturing is preferred, packaging only after component finish and testing
- Interlinking several injection molding machines with individual surface refinement systems to use different cycle times with maximum capacity
- Creation of testing and packaging areas for group work/improved staffing efficiency
- Specific requirements for assembly technology
- Basic parameters of the machine platform:
    - Width of single constructions in the grid dimensions: 600 mm, 800 mm, 1 000 mm, 1 200 mm, 1 500 mm, 2 000 mm and custom machines (only after release by NIDEC)
    - Depth of single constructions between 600 mm and 2 000 mm and custom machines
    - Height of facilities < 2 250 mm; this should not be exceeded so that energy supply channels can be routed at the standard height of 2 450 mm
- Basic machine frames can be driven under with pallet trucks to allow for specific positioning within assembly systems in Production.
- Routes for direct personnel must be reduced to a minimum within their workflow. For this purpose, provisioned material must be accommodated within the assembly machine wherever possible

- Material logistics is handled from the outside of the assembly systems; it uses space for containers in areas behind assembly machines that do not need the full depth of the available space
- Appropriate discharging options for empty containers must be planned at floor level
- Nidec standard systems must be used for provisioning
- Ergonomic positions must be created in the assembly area for the components defined in the project-specific part and their containers; it must be possible to top them up from outside via rails as of a container footprint of 300 x 400 mm
- Provisioning of material in wheeled wire mesh bins must be considered to allow sufficient maneuvering space and additional parking space
- An uncluttered view and communication options for the assembly staff must be ensured

4.2.4.3 Specific requirements for test technology

- Technical testing equipment must be designed to be stand-alone, unless it is part of a complex overall system. Within interlocked systems, mechanical decoupling must be implemented where possible.
- Machine areas with mechanical adjustments must be decoupled from ambient vibration (a passing forklift truck must not have any influence on the process).
- The existing shop floor lighting must be supplemented to ensure adequate lighting of the test areas

4.2.4.4 Specific requirements for interlocking systems

- The layout planning for transport systems and interconnected systems must include the sections required for decoupling certain areas. In line with the specific requirements, options for removing/feeding in material from/to additional buffers must be designed for
- Where production facilities are arranged in parallel within the transport system, each of these modules must be designed to switch off individually without affecting the operations of other modules (to be implemented using switches)
- If the transport system is used for several different products, each of these products can be individually changed over without affecting the others.
- The transport system must use a modular design with route sections that enable adjustments at a later stage.

4.2.5 Technical status display for complete system

For more complex systems, a display system must be installed that allows the machine operators to identify machine jams from any position on the system and to report faults in terms of type and location if necessary. Optionally, an additional audible signal can be activated. The display system operates as a satellite of the existing operator interface on the system and has no input options.

In addition, information from the machine counter for OK parts and rejects can be added (if required for the project).

4.3 Installation technology

- Cable and hose guides and installation must be attached so as to keep the floor free.
- The entire installation takes place in enclosed cable ducts; all exposed cables and hoses must be bundled and routed. EMC compatibility of data and sensor cables must be taken into account.
- All electronic sensors, actuators and drives must be designed to be pluggable
- The cabling system must not have cable connections in locations that are difficult to access.

- Walkable cable ducts (including ducts that are not routed on the ground) must be slip-proof and safe for loads
- All cables routed in drag chains must support dragging.
- All cables routed in drag chains must be separated by appropriate separating webs. Bundling of cables within a drag chain is not permitted.
- Control cabinets must be arranged within the base frame (if possible).
- A document compartment must be attached in the control cabinet to hold the hardcopy of the electronic documentation.

4.4 Technical cleanliness of the operating equipment

The requirements for technical cleanliness of the production equipment are regulated in Nidec directive HQ-G-C4-10.

The design and implementation of the operating equipment takes into account the required cleaning in Nidec's Production. This includes appropriate operating modes and accessibility, avoiding hard-to-clean areas and providing cleaning aids.

Based on the provisions the project-specific requirement specification, the following can also be installed:

- Quick coupling for operating a compressed air-powered vacuum cleaner including the vacuum cleaner system,
- Electrical connection for an additional vacuum cleaner with a 127 ~ 240 V/ 400 V/415 V/440 V power supply outside the control cabinet
- An integrated cleaning unit with a cleaning cycle built into the production process, air treatment and connection to the control system (for automated production facilities).
- On delivery, the operating equipment must be thoroughly cleaned inside and out.

4.5 Energy management

- Equipment must be designed to achieve the highest possible energy efficiency.
- Suppliers must provide products and solutions for recording, analyzing and reducing the actual energy requirement.
- The respective efficiency classes must be observed for electric motors (IExx; International Efficiency) according to IEC 60034-30. An amortization calculation must be used to discover whether using a motor with a frequency converter makes economic sense for variable-speed operation.
- In order to centrally switch off the equipment, in coordination with the customer a supply point must be provided in a control cabinet with all the feature blocks (electrical power, compressed air, vacuum, PC jumpers, ISA net, etc.).
- In the case of extensive interlinked systems, in coordination with the customer a decentralized switch-off must be provided (otherwise, the entire plant will come to a standstill if there is a fault).
- The compressed-air supply should be centrally located to enable the machine / equipment to be disconnected from the power grid over the weekend.
- Fans on the control cabinets must be equipped with a thermostat to ensure they only function if the temperature in the cabinet requires it.
- Workplace illumination for assembly cells must be designed with LED technology and must allow for the lighting to be switched off by an Operator or automatically (e.g. after a defined waiting period without process performance).
- Use LED light sources instead of incandescent lamps to display operating states, for warning lights, etc.

- Process content, like plasma treatment, vibratory feeders, feed rails (including infeed or discharge conveyors) must be used exclusively pulse-controlled as a continuous Operation is not permitted.
- Standby mode must be provided in order to set consumers in an energy-optimized operating state during standstills (comparable to PCs).
- Where possible, drives must be disconnected from the power supply in the event of a standstill.
- The overall system must be optimized if pumps are used (motor, drive, pump, circuit). It is preferable to use pumps with partial load operation instead of a choke system with a speed control. Use highly efficient energy class A pumps (Energy Efficiency Index, EEI) whenever possible. The supplier must submit the extra costs together with an amortization calculation.
- To reduce unnecessary energy consumption by idle conveyor belts (product carrier jam on the conveyors), the following function must be provided:
- Every belt (not cross belts or bypass) must have a sensor activated by the passage of a product carrier. The sensors initiate a timeout counter in the PLC. If no product carriers are detected after a set time, the PLC switches off all conveyor drives. Pressing the "belt on" button switches the belt drives back on and resets the timeout counter.
- Drive motors with transmissions must be designed with a straight bevel gear pair instead of worm gearing (more efficient). The supplier must submit the extra costs together with an amortization calculation.
- Diameter-optimized pneumatic and hydraulic cylinders must be used. The use of electromechanical elements must be investigated as an alternative.
- The power and compressed-air lines must be as short as possible inside the machine / unit (the longer they are, the greater the energy loss).
- The proportion of moving masses in the operating equipment must be kept to a minimum.
- The supplier has to provide an estimate of power and compressed air requirements for the offered equipment per operating hour at full load in the quotation.
- The quotation has to list more energy-efficient alternatives for the installed components and/or suggest alternative, more energy-efficient processes for meeting the requirements.
- As part of the operating equipment acceptance by Nidec, the supplier has to submit a measurement report for the actual energy and compressed-air consumption.

4.6 ESD-compliant design

Requirements for operating equipment (ESD compliant machines and equipment) are mentioned in the project related specifications. Always use equipment and operating materials which are earthed or electrostatically dissipative. In addition, the self-discharge of the equipment and operating resources (how quickly the load drops back to an uncritical value) must also be taken into account.

A table surface with a conductive, EPA ground-connected resistor is used to ensure an ESD- and design part-compliant design of the workplace: $1.0 \times 10^5\ \Omega \leq R_G < 1.0 \times 10^9$.

The ionization process must be built with components from the list of preferred products. The function and cleaning effect must be validated within the scope of operating equipment acceptance.

4.7 Marking

- Operating equipment must be marked.
- Switching elements (valves, switches, control devices) must be unambiguously marked with their function; appropriate warnings must be affixed
- Sensors, valves, actuators, etc. must be marked with index numbers as per the documentation so that the existing marking materials can be used in case of replacement.
- The marking language is appropriate for the ordering production site/plus English if expressly required.
- The required workpiece-specific accessories, the required production aids and tools must be captively labeled.
- All markings that must be made for safety reasons are subject to DIN 4844-1 "Graphical symbols - Safety colors and safety signs - Part 1: Observation distances and colorimetric and photometric requirements".
- Programmable motion devices must be marked with the appropriate axis designation and the respective direction of movement.

4.8 Accessibility of the machines for repair work

It must be possible to lift all heavy assemblies and machine elements (greater than 15 kg) upward or laterally out of the machine space.

To make this possible, note that installations (cable ducts, coolant lines, hydraulic pipes/hoses, etc.) are routed so that the units are freely accessible from above (with an interface if necessary). The installations must not be routed on both sides of the units to be removed.

Suitable access points to the production equipment must be provided (for example, upper door frame easily removed with tools in order to be able to drive through with the raised load).

Assembly equipment with safety guards must be accessible on both sides, in order to quickly perform adjustment and repair work.

4.9 Assembly equipment and maintenance aids

- Tools for maintenance and repair, as required for removal of components on production equipment, must also be supplied (motor spindles, synchronous linear motors, inaccessible motors, fans, pumps in noise protection cells, etc.).
- For the removal and installation of components of more than 15 kg weight, an assembly beam and removal aid (min. 600 mm) must be provided for the on-site crane trolley. It must be possible to provision the assemblies at an easily accessible point for outbound transport.
- Adjustment aids and tools required for setting up, calibrating and operating the systems are part of the scope of supply (for the system and not for the product).
- Adjustment aids for adjustment devices must be delivered with an upper and lower tolerance (if needed).
- Special tools are included in the scope of delivery.

4.10 Assured supply of spare parts

The spare-parts supply, from the supplier or directly from the manufacturer, for components installed in the machine is ensured for a minimum period of 10 years. Alternatively, the supply can be ensured by means of components with equivalent or superior quality and performance.

In the case of parts manufactured specifically for the customer, reproduction must be guaranteed or the required information for a reproduction by Nidec must be stored in the documentation.

4.11 Means of transport/lifting gear for project-specific equipment

Project-specific operating equipment or exchangeable machine parts weighing more than 15 kg must be moved into the working position of the standard machines using means of transport/lifting gear. To allow this to happen, the project-specific equipment must be fitted with corresponding attachment options, guides and transport locks. The transport and storage modules must be designed to match these. If soiling is possible, appropriate covers should be provided for storing the jigs.

- Changing carts will be defined by the ordering plant. The design must be agreed between the ordering party and the supplier.
- Changing carts must have a height adjustment. Machines are height-adjustable to compensate for uneven floor surfaces. Correspondingly, the changing cart must also be height-adjustable so that the jig can be set up without any problems.
- A cover (hood) must be provided for the jig to prevent soiling on the changing cart during storage.
- The load carrying capacity is at least double the planned weight of the exchangeable device
- The replaced device must not protrude beyond the changing cart.
- To change the device, the previous device is positioned on the change car which was previously pulled to a position in front of the machine and mechanically secured to the receiving plate to prevent slipping. The change cars are exchanged at this position, so that the new device can be pushed back onto the machine from its change car alter releasing the transport lock. Height differences must be compensated for by the change cars.
- The change car has a transport lock for the device, as well as brakes for the wheels on the car.
- If the interchangeable equipment is stored in appropriate storage units (e.g., planetary paternoster, compartmented paternoster, etc.), the transfer interfaces must be adapted to match the trolley.

4.12 Transport and delivery of operating equipment

- All machines or knocked down machine parts must be transportable using standard trucks incl. the necessary transport packaging.
- The corresponding maximum dimensions and weights apply to shipping in sea containers. Closed containers are preferred (no open tops).
- The lifting equipment available at the plant is normally available for unloading trucks. For its use, the exact weight of the packages must be known in advance. In general, the supplier remains responsible for heavier packages or crane unloading.
- Operating equipment must be transported without dismantling to the extent possible. If transport is only possible in knocked down state, the interfaces must be kept as simple as possible (electrical connections using plugs, positioning aids for mechanical modules, etc.).
- Assembly equipment is always transported in upright/suspended position, where necessary with appropriate dismantling of the upper areas (this must be designed for accordingly; attachment aids must be used for securing in dismantled condition; the dismantled residual height allows for transport in closed containers including packaging).
- Movable machine elements (e.g., robots) have a defined transport position and can be secured in this position.

- Cells up to 2 m^2/2 000 kg must be transported with a fork-lift truck to allow for rearranging and relocating without any major overhead. The center of gravity must be explicitly marked, if it is not centrally located. Free space must be left on the underside for the forks.
- Separate control cabinets must be transported with fork-lift trucks and have an additional permanent screw-in thread for eye bolts for suspended transport as of a height of 1.5 m.
- Attachment points for lifting appliances must be clearly marked on the machines, as per the loading points on the frame.
- Slings and particularly aids for moving the operating equipment are the responsibility of the supplier.
- The machine packaging must be matched to the necessary conditions of transport.
- Machines with a transport profile of 3 000 x 3 000 mm are usually manageable. If these dimensions are exceeded or for longer machines, the contractor must coordinate delivery with the client.
- The floor load of the machines must be coordinated with the client from a value of 2 000 kg/m^2 or in case of high point load.

4.13 Installation of operating equipment

If possible, the machine must be designed without the use of fasteners, i.e., not anchored or doweled. The installation elements must be quoted for or provided. If the machine cannot be installed without fasteners, the type of anchoring provided must be agreed upon with Nidec. Dowels/anchors that are approved by the building authorities must be used.

12 weeks before starting the installation work, the contractor must submit the corresponding detailed documents (such as layout, floor plan with connection data, required media, energy and network connections, assembly plans, and machine specification sheets). The contractor must thus inspect the installation location of the assembly line as early as possible in collaboration with Nidec to check the requirements.

If construction work and protective devices/coatings are necessary, the contractor must check these for correctness/integrity before the delivery of the assembly line.

The scheduling and safety coordination before and during the installation work must be carried out in accordance with the Employers' Liability Association (BGV) regulations and in collaboration with Nidec.

The customer handles the internal transport of the assembly stations and the energy connections.

The contractor must provide the required tools, measuring, and testing equipment for installation.

If hazardous materials are used in assembling assembly stations, these must be reported to Nidec with the designation, type, quantity and storage location before beginning the assembly.

All welding, cutting, power cutting and soldering work must be reported to the plant fire department in order to prevent fires.

Safety measures must be taken by the contractor. Beyond this, the instructions for third-party employees apply.

If materials that can affect the well-being of the employees in the vicinity are used as a part of the additional assembly of the assembly stations, the contractor must ensure that the unpleasant effects of these materials are reduced to a minimum by implementing suitable measures. This also applies to noise and vibrations.

5 Safety system design

5.1 Safety system

The processes, sequences, and automatic and manual handling behaviors must be designed to reflect the current state of standardization, the legal framework and the state of art. This is achieved with the following measures (the list is non-exhaustive):

- Mechanical safety devices must be used to make danger zones inaccessible/accessible only after removing the safety devices with tools.
- If access to a particular machine area is regularly required, appropriate, mechanically locked and electrically controlled access doors must be provided.
- If access occurs in each production cycle, the access door of the machine must open automatically; closing must be servo-assisted.
- If there is a risk of a person remaining inside closed safety equipment, a mobile emergency stop facility must be installed inside the danger zone.
- If safeguards with a visually-only effect are intended, due to special conditions, the necessary safety margins must be identified and implemented by measuring the post-run time in addition to providing appropriate warnings and training. All relevant operating conditions must be checked by means of post-run time measurements.
- In the scope of the design, a full analysis of the potential risks must be conducted in line with the legal requirements; the production equipment must be designed on the basis of the results.
- The structural layout of the production equipment must ensure that all necessary monitoring and work can be carried out from safe areas or under safe conditions, because there is no incentive to manipulate the operating equipment.

5.2 Safety functions

5.2.1 Personal protection/ergonomics

In line with the risk analysis, the machine's safety facilities protect the employee against hazards.

- Closed panes provide protection against the risk of material being ejected out of the machine (e.g., plastic out of an injection molding machine).
- The positioning of the main work areas in an ergonomically Optimum position and orientation helps the employees avoid health problems.
- Designated access points give employees access for maintenance and repairs.
- Openings in the enclosure are only approved after a complete stop of the moving elements, or a shutdown of the processes.
- Accessible machines have an option for triggering an emergency stop for setup mode from inside the machine.
- For setup mode, the permissible travel speeds and energies are reduced to the permissible level.
- Safety distances to hazards must be designed in accordance with options for access. Different machine states/work situations in the cycle must be separately assessed.

5.2.2 Assembly protection

The machine's safety system secures the production process and protects machinery and products from undesirable manipulation by employees. This safeguards the sequence, execution and outcome of the production process to allow the machine to assess the assemblies, after evaluating its sensor output, and deliver them to the downstream work flow:

- Controlling the locks an access areas so that the process can be correctly and completely run, and sensitive machine parts can be secured (access released after completing the cycle)
- Clamping/releasing of component locks for the correct handling of components
- Covers moved by the machine for protection against accidental movements and contact

5.2.3 Environmental protection

Laser safety

The requirements of IEC 60825-01 and the documents referenced therein must be implemented in the design of operating equipment.

All laser systems of classes 2 to 4 are only permitted to emit light radiation in protected areas. This includes doors, locks, specific viewing windows. A monitoring facility must be provided in the safety cell for the laser to allow monitoring and adjustment of the process. This can be a laser protection window (NOT preferred), or an integrated camera (preferred solution) with a display outside the protective paneling.

The laser source must always be integrated into the safety circuit of the machine.

Laser scanners or other class 1 laser systems must be integrated in such a way so that no employee looks directly into the laser beam during normal operations.

In all access areas and at the laser source, sufficient hazard warnings of the risk emanating from the laser must be displayed.

Chemical safety

When using chemicals, the appropriate hazardous material data sheets must be observed.

- Areas in which liquids are used must be protected with a sufficient collection tray within the machine. Removal and cleaning of the tray must be possible.
- For technical gases or the extraction of escaping gases and/or particulate matter, extraction and treatment purification must be ensured in line with the safety data sheets. The exhaust air is discharged outside the production areas above roof height. Monitoring of the extraction system must be integrated into the safety circuit of the system.
- Extractions for reactive gases (solvents, plasma flames, etc.) must be additionally equipped with operating time monitoring so that regular maintenance and inspections are displayed and carried out.
- All work areas with chemicals must be clearly marked with the materials used; staff must be trained with respect to the potential risks.

5.2.4 Safety zone design

The safety zones for these modules also have a modular design based on Nidec's modular operating equipment assembly matrix. Interlinking these production modules also requires integration with safety engineering:

- Safety circuits and their areas must be clearly marked.
- Safety functions within the designated area of a safety zone are interconnected; this means that when automatic operation is switched off, all movements in the security area stop at the end of the cycle and action can be taken in the system in the safety zone without risk.
- The transitions between safety zones must be designed so that both areas can produce independently under normal circumstances; i.e. when one area is switched off, the neighboring area can continue to work.

- Automation areas adjacent to safety zones must be protected from within the disconnected safety zone and from outside the machine. Alternatively, the connected areas must also be switched off.
- If a neighboring area can be reached through a switched-off area, then additional safety systems must be integrated to guarantee the safety of the system that is still working.
- If a disturbance affects several areas, these (and only these) must be switched off.
- The shutdowns should take place at the end of the cycle where possible.
- Mechanical locking systems are typically used to protect work areas in case of fast movements and/or movements performed with high energy.
- Visually safeguarded or collaborative systems must be visually marked at their limits; appropriate warnings must be displayed. Visual feedback from the system shows the system operators the status and access permission status.
- The zoning and shutdown concept must be presented in the scope of the Nidec design release and is released by Nidec. In case of critical designs, the appropriate professional association must be called in.

5.2.5 Safety enclosure

Safety enclosures below the machine's base plate or <900 mm above the shop floor must be designed to be opaque.

For the operating and display units in this area, corresponding transparent protective doors must be installed in the safety enclosure (no safety significance, only for protection against accidental contact).

Safety enclosures above the machine base plate or >900 mm are designed according to their function:

Functional zones	Design
Separation and protection without visual requirements	Sheet metal with a suitable surface coating, and additional insulation properties if necessary
	Stainless steel in case of special contamination
Robot cells in which no material can pass through the grating	Steel mesh (exception can also be used at floor level)
General protection zones	Transparent Makrolon, conductive in case of ESD requirements
Special functions: • Laser processing • Optical tests	In special cases where an additional protection function exists (e.g., laser processing, dimming, etc.), the protection must be designed to reflect the stricter requirements.

- In all cases, staff must be able to view the process in the cell from the main control panel position.
- Moving protective devices are monitored as a general rule.
- In order provide protection in case of dangerous machine movements with increased post-run times, or other significant hazards, additional locks must be provided, that only release access when the machine is at a standstill.
- The opening movement must not obstruct the employee when performing their task on the open machine; the opening area allows ergonomic performance of the work.

- As of a protective covering height of 2 200 mm, a top cover is no longer required, unless the purity requirements or process require this in the intended production area, or overall extraction/ventilation is required.
- For automatically transported parts, an enclosure is provided in the transition area between cells. This prevents contamination of the workpieces in the entire transport area in which the workpiece is not yet sealed.
- Protective coverings are designed in such a way that optimum accessibility with open protection is possible at all necessary points.
- Protective coverings with mechanical fasteners must be implemented as per EU Directive 2006/42/EC with appropriate captive fastening elements (e.g., quarter-turn lock) and tool-based Operation.
- Removable protective covers must be designed to have a manageable size.

5.2.6 Notes on operation, maintenance and regular function checks

- In order to perform maintenance, changeover work, repairs and cleaning, the operating equipment must be switched to specific states that allow such work. The necessary actions, the system and functional relationships must be documented as instructions in the maintenance manual.
- Active data acquisition systems are listed in the manual as part of the regular functional check.
- Components with a statistically assured safe function must be marked in the maintenance manual with the permissible period of use. The same applies to passive elements, which have a reduced working reliability after a certain period of use (e.g. laser shields, brakes, etc.)

5.3 Safety devices

- For safety reasons, the design must provide for access to the system for maintenance out of the planning phase; this must be implemented by the commissioning phase (see 2006/42/EC DIN EN ISO 12100)
- For reasons of accident prevention, where required by the hazard analysis and risk assessment, vertical and inclined units must be equipped with an electrically monitored, automatic lowering lock. The lowering lock is active at least in the home position of the unit or tool/mold, or in the workpiece exchange position and only when the safety door is open.
- Covers must be individually removable.
- For testing and replacement of chains, belts and ropes, an option must be created for keeping the weight balanced.
- Automatic, mechanical, and electrically monitored zone protection is required for loaders that serve two machines.
- Safe access to the modules must be ensured for all machinery and equipment (maintenance platforms) as per Machinery Directive 2006/42/EC DIN EN ISO 12100.
- Walkable areas:
  - Walkable areas must be equipped with grids as per DIN 24537, anti-slip class R12.
  - A circumferential baseboard with a height of 100 mm must be provided as per DIN 4420.
  - Fall protection (railings), including a self-closing door at the access point, must be provided.
  - The minimum depth of the walkable surface must be 600 mm.

6 Adaptation of process technology and product-specific equipment

6.1 Interface to process engineering

The diversity of process engineering devices makes a standard interface virtually impossible. For this reason, the following design guidelines should be observed during the Integration:

- Use of modules that are pre-assembled and then installed.
- Process technology is not used as a supporting component for the machine, it can be dismantled without impacting on the structural integrity of the machine.
- The Interfaces must be kept to a minimum so that a replacement/updates can be sensibly carried out.
- A clear differentiation allows the viewer to quickly distinguish between process engineering and the basic machine.
- The basic machine is designed and implemented for the optimum process.

6.2 Interface between machine and product-specific equipment

- The interface between a product-specific piece of equipment and the machine is always clearly described:
  - Carryover of a previously implemented interface solution in line with the provisions of the project requirement specification
  - Use of common, commercially available standards through the deployment of catalog articles (that must not be modified)
  - A new interface to cover the project-specific requirements may only be introduced after consultation with project management and following standardization.
- The interface has, in all aspects, reserves for expanding its current task (sufficiently mechanically stable for full load, electric contacts in reserve, reserves in the bus protocol for communication)
- Assembly of the device is supported by centering guides/lead-in chamfers and does not require adjustments to achieve the process position. The use of mandatory tools to change the project-specific device is permissible only in exceptional cases (the tools must then be connected to the machine and included in the scope of delivery!)
- The replacement of the project-specific equipment is subject to the normal ergonomic requirements. All necessary work areas are visible and accessible by staff.
- The precision of the interface complies with the requirements of the process; this interface should make a max.15% (reference value) contribution to the overall tolerance.
- The equipment on the machine must be protected with mechanical captive locks. Position monitoring is necessary in case of higher dynamic load.
- Process-specific equipment is typically coded and checked by machine control system for congruence to the selected product range.
- The media supplies for the project-specific equipment must be combined if possible.
- The media interface must be positioned in a user friendly manner, clearly fastened in its position on the machine (e.g. hose adapter holder on KSP tools, connector bracket on the robot quick-change adapter, jig connector plug bolted onto jig plate, etc.)
  If adaptation of the media is possible simultaneously when positioning the holder, this should be given preference.
- Exposed operating equipment components must be protected against damage and unintentional adjustment (e.g., pneumatic and electric connections, scanners, cylinders,

sensors, etc.). If necessary provide scanner holders on the device (Note: "The scanner is part of the machine").

6.3 Product-specific setup

- Holders and product-specific equipment must be regarded as partially complete machinery within the framework of conformity assessment. A declaration of incorporation with complete documentation is therefore always included in the scope of delivery.
- It must be possible to position and secure the workpiece on the jig without the Operator having to discover the correct position. Appropriate lead-in chamfers, guides and free space must be provided
- "Blind parts handling" must be avoided in all circumstances.
- The inserted work piece is aligned in the holder using the main component coordinates and fastened at the attachment points. Excessive determination of the position must be avoided; the tolerances of the individual components remain without impact on the mechanical stress of the overall system. If possible, deviations in the component (distortion, shrinkage) are compensated for by the holder structure and do not cause mechanical stress.
- The distribution of gripping surfaces between grippers and holders must be matched during planning. The machining process takes precedence over the handling process.
- It must be possible to repeatedly position and secure the workpiece on the holder without the Operator having to discover the correct position.
- The precision of the component holder contributes towards ensuring the capability of the current process
- The "Poka Yoke" philosophy must be adhered to/provided completely (failure avoidance, "lock and key principle")
- The fixture shall be designed considering the current CAD data of the device.
- Component variants are monitored in the holder with the simplest possible means.
- The basic part is generally locked for monitoring further use as an OK/NOK part.
- The workpiece and the workpiece holder must not be soiled or damaged by machining processes or the like. The holder material and the holder elements must be set up to match the component material.
- The mechanical strength of the component holder is designed for the occurring loads with the required safety margins.
- The occurring process influences must not change the holder over time (deposits at mounting points, lack of fatigue strength, different bending in the process, etc.)
- No particles or abrasion must be caused by the part locking mechanism or other processes on the fixture.
- Mechanical wearing parts (gripper jaws, etc.) and holders must be hardened, marked, pinned and easily replaceable. A clear installation position is to be specified through appropriate constructive measures. Adjustment work must be avoided.
- Adjustable elements in the holders must be designed to support guided adjustment.
- The workpiece must be easy to remove after the machining process.
- The product specific facilities must be designed to be handling- and-storage friendly; clear protrusions and exposed, sensitive components must be avoided. Clear surfaces must be provided for storage.
- Marking of the jig is mandatory. The product-specific operating equipment number must be added after "Operating equipment no.:", and the device part name and/or device part number to which the jig belongs must be indicated after "Belongs to:". Note: The product-independent operating equipment number of a Nidec standard machine must not be specified after "Belongs to:", because the jig can be used on any similar Nidec standard machine.

- Jig parts or additional components (especially screws) dropping on printed circuits must be ruled out by systematic measures in the assembly process. If a decision to the contrary is required, this can only be taken by the series production project manager AND the quality manager of the manufacturing plant.
- The populated PCB's load in devices due to locking, clamping or the process must not exceed the values listed in design and process guidelines for sensitive SMT components.
- It must be possible to handle changing devices with an overall weight <15 kg manually thanks to appropriate access zones. Devices weighing > 15 kg must be equipped with attachment options for lifting gear. If the weight exceeds 15 kg, the quotation must disclose this fact ("Additional equipment needed").
- Project-specific parts and components must be documented in detail so that Nidec can independently reproduce or independently procure each part. Additionally, the positioning and indexing system must be documented in the assembly drawings (as per the release, before production)
- Additional, special tools for the equipment used by the supplier, are included in the scope of delivery, as is a contact person for the supplier or a technical description for a replacement production.

6.4 Change-over of production equipment

- Change-over of a production line depends on the technology used, the scope of the technical modifications, process times, and amounts of material used in the system. The duration is measured from the last predecessor component to the first new component in the same place and with the same status (typically at the system discharge point).
- There should be as little change-over work as possible.
- Accessibility for the change-over is ensured for the employees; mechanical locating aids simplify tooling.
- It must be possible to change over and secure changers without using tools.
- Indexing systems must remain the same across various variant systems
- A change-over process is carried out without dismantling actuators, the sensor system or marking equipment.
- Changers are queried for correct tooling to match the new variant specification and released by the PLC
    - Continuous change-over:
      After stopping the inflow of new material, the change-over starts in the control technology, equipment and logistics areas. Stations are gradually converted to the new version one by one up to the end of the contiguous production area.
    - Change-over with downtime:
      After stopping the inflow of new material, the remaining material is processed in the contiguous production area, until there is no more semi-finished material available. Logistic change-over occurs wherever possible. The equipment, control technology and material is then prepared, for ramping up the new variant
    - Tooling in a shared interlocked system:
      Interlocked areas with multiple material flows and/ or target areas can be changed over as single supply and discharge systems during ongoing production. There is no influence on the manufacturing variants whose production continues.
- All production systems can be run empty of semi-finished material, in order to enable a controlled shutdown. For provisioning areas that are difficult to access, control routines must be integrated in order to retrieve unprocessed material from the system back to provisioning.

- Equipment that has been adjusted and checked must not be unintentionally adjusted by the changer-over process. It must be ensured that parts that have been correctly produced with the first cycle are already available after the change-over. To achieve this, the change-over process must not influence the process (and must work correctly after the appropriate preparation time and start-up process design, e.g. preheating in the case of plastic injection)
- The times for change-over are listed in the individual requirement specifications.

6.5 Logistics Integration

6.5.1 Change-over friendliness

- Material provisioning can be handled by staff without special effort
- In the course of change-overs, logistics staff can autonomously retrieve all means of transport from the systems.
- Automated feeders must be equipped with protective covers that can be removed for cleaning purposes. Automatic operations continue to run with the protective covers open

6.5.2 Mix-up proofing

To identify the required materials, appropriate areas must be provided for marking.

6.5.3 Provisioning scope

- Delivery containers are typically adapted in terms of design and size to the technical and logistics requirements. The provisioning systems must be suitably designed for the specified delivery containers
- The intended provisioning autonomy time is 60 minutes. The supplier must seek an alternative if this is clearly exceeded. If the time is below this, the supplier must propose alternatives to the standard
- Within this time, the operators are permitted to replace the containers from their normal location.
- In line with the project-specific specifications, individual material supply systems can be equipped with an automated call-off system for new material.

6.5.4 Automated provisioning

6.5.4.1 Bulk goods feeding

- Feeders must be equipped with jam sensors. Signal output for lack of material. Switch-off if the line is full.
- Buffer sections must always be covered.
- Sorters on feeding systems must be compact so that the project-specific feed performance can be reliably achieved. Buffer quantities must be provided using separate hoppers.
- Sorters and hoppers must be equipped with a transparent and folding panels to prevent dirt and noise. Covers for cleaning and filling must be provided.
- Linear rails and sorting facilities should be hardened, pinned, and easily replaceable, where possible. Adjustment work must be avoided.
- Bulk feeders must be designed with a capacity reserve of at least 50%.
- Sorting operations must be executed without air support.
- Stepped feeders must be given preference over vibrating helical conveyors

6.5.4.2 Tray feeders

Tray feeder systems must be agreed upon with the specialist departments to reflect the required number and height of trays to ensure autonomy times.

6.5.5 Manual provisioning

- It must be possible to remove empty containers manually within the constraints of normal ergonomic load
- Storage areas must be provided for any additional packaging material
- Material provisioning at the rear above the work top is permitted
- Provide interfaces for the fastening provisioned materials from the rear of the machine. In the area adjacent to the holder, space can be provided for small parts containers. The type, position, orientation and size of the containers must comply with project-specific guidelines.
- The objective is to be able to provision a supply of goods for 1 hour of full production in/at the work station, without needing employees at the rear to exchange or push in new delivery containers. The disposal of empty containers, which is performed on separate paths from the system is exempt from this.

7 Mechanical components

- For all machines and equipment the "wear resistance" and "ease of repair" of the system must be given priority with a view to the requirement for high availability.
- All lubricants must be silicone-free as per DIN 51 517-3.
- The use of silicone and similar materials for sealing the systems is not permissible.
- Color scheme requirements from the plant-specific requirement specifications take precedence
- Standard parts must not be changed.
- Parts may only be fastened on sheet metal and profiles if stable connections are used (thread depth min. 1 x Ø). Leaktight to the outside in wet processing.
- Only tapered and parallel pins with internal threads may be used.
- Covers must be designed for pluggable fastening; it must be possible to remove them without tools in safeguarded areas (e.g. latches, spring bolts or similar).
- Covers must be individually removable.
- Plant components that require greater mutual positional accuracy must always be pinned.
- Standard aluminum profiles are not permitted as design elements in use cases with dynamic loads (e.g. test beds) or where increased positioning accuracy is necessary. Load-bearing machine constructions can only be built from aluminum profiles following consultation with Nidec. Threaded connections can loosen due to vibrations and machine dynamics. Pinning is not possible here if greater positioning accuracy is required.
- Any media discharge (assembly oil, engine oil, test oil, adhesives, sealants, and wash water, cooling-lubricants, fuels, etc.) from the machine must be prevented by appropriate measures.
- The contractor is obligated to provide all technical documents for the execution of the repair work as well as for manufacturing spare and wear parts, including contractor's specific "standard parts", free of charge.
- On request, dimensioned drawings which are ready for production (or DXF torch cutting/cutting files) must be provided, also for "standard parts".

7.1 Drives

7.1.1 General requirements

- The maximum torque of the drive must be adapted to the powered mechanism, especially where gearing is used.
- In terms of drive types, it must be ensured that no consequential damage is caused by the drive output in the event of a crash/accident
- For each type of spindle (feed, rotary axes and main spindles) appropriate measures must be taken to allow controlled, smooth acceleration and deceleration of the mechanical systems. Soft start-up must be provided in the case of non-controlled main spindles. For servo axes (also main spindles, rotary axes), jerk limits (limits to the change in acceleration) must be enabled on the drive machine data.
- Drive motors must be easily accessible.
- Re-tensioning options must be ensured for belt drives or chain drives.
- Driven add-on parts, such as pumps, must be adapted to the standard flange and standard shaft diameter of the drives.
- All drive components in particularly tough ambient conditions must be protected by suitable covers that prevent contamination by chips, liquids, dust, weld spatter, and paint spatter so that maintenance-free operation is guaranteed.
- Friction lining/slip clutches must not be actuated during operation; they must not be used in wet areas.
- Motors and gearboxes must not be used instead of a second bearing.

7.1.2 Overload protection

- Axes with an absolute measuring system must not have overload clutches.
- If overload clutches are unavoidable, then it must be ensured that zero point referencing is possible (sign with details).
- Collision protection for robots and loaders must be coordinated with the specialist departments depending on the process.
- PTO and drive torques with process-related load fluctuations must be protected by suitable interlocking couplings with electrical feedback and forced locking.
- Axis identifier
    - A NC/servoaxis overview must be created for systems with several NC/servoaxes.
    - The NC/servoaxes must be marked with X, Y, Z... and with the +- direction.
    - If NC/servoaxes are used in a processing unit, the zero-point marking and the dimensions/fully assembled length must be permanently and clearly visible).
    - The zero point on each NC/servoaxis of a loading system must be marked with a vernier scale (function as per a vernier caliper).

7.1.3 Motor-independent brakes

Where brakes are used they must always be designed as service brakes. The function must be designed as a holding brake (no positioning via the brake).

7.1.4 Drive belts

- The wrap angle of the belt must be no less than 90°.
- The pulley diameters should be as large as possible.
- Only oil resistant drive belts can be used.
- A frequency value for belt tensioning must be visibly displayed.

- When designing the units it must be ensured that machine elements capable of releasing liquid (oil, cooling lubricants, etc.) (also in case of leakage), are not installed close to the drive belts.

7.1.5 Pulleys

- Aluminum must not be used for pulleys, except for toothed belt pulleys for transport equipment.
- The pulleys for drive belts must be manufactured from stainless steel, steel or gray cast iron. The material selection of the pulleys must match the application.
- Shaft hub connection with clamping set.

7.2 Transmission

7.2.1 Gearbox with flange/shaft for mounting different drives

- Only spur and bevel gears are permitted, preferably of structural shape B3.
- Output side exclusively with a solid shaft, for bevel gear units to side A.
- Requests for a quotation from the transmission manufacturers must include a note on compliance with the technical delivery specifications for the respective plants.

7.2.2 Geared motors

- The design of the motors for the gearboxes must conform with the Drives section.
- Geared motors must not be suspended.
- Shaft hub connection with clamping set.
- Sizes and gear ratios are shown in the material release lists for the plants.

7.3 End position limits

End position limits must be provided for slide units guided on profile rails. Slide units with a roller bearing guide must not run out of the guides (end stops, but not on the guide carriage).

All end positions must be implemented using screw-type fixed stops with defined damping.

7.4 Conveying technology

7.4.1 General information

- Enclosure for preventing contamination of workpieces in the entire transport area where the workpiece is not yet closed.
- Stoppers and separators for workpieces or pallets must be equipped with dampers.
- Supply and return locks must be installed wherever passages in lines and swivel areas exist, and in case of roller conveyor-level differences.
- In case of electromechanical drives, damage to the transport system due to drive overload must be prevented.
- Only DIN / ISO chains are permitted.
- Chain locks/links must be color highlighted (e.g. with plastic Clips).
- Re-tensioning options must be ensured for belt drives or chain drives.
- The buffer sections must be kept as short as possible to avoid high forces on the stoppers/separators. The materials, weights and workpiece speed must be considered during the design.

7.4.2 Lifting and sliding transport

- Where lifting beams are mechanically driven, overload protection must be provided (to prevent mechanical damage)
- NC/servodrives are used by preference for lifting conveying.
- The workpiece carrier (e.g. pin) must be the weakest link of the transport system (predetermined breaking point)
- Replacing damaged workpiece carriers must be simple, fast and possible without reworking the transport belt (insert segments in the transport belt). The holes for the pins in the transfer bar must not have any blind holes.
- The carrier and idler rollers must be well secured against dropping out and loosening (e.g. cam rollers with a lock nut)
- The bearings on the lifting linkage and transport rollers must be lubricated.
- Rotators integrated in transfer systems must be mechanically adjustable (angular position)

7.4.3 Roller conveyor for the workpiece and the workpiece carrier

- Lightweight design roller conveyors: Solid profile (split profile in cramped and difficult to access areas).
- Heavy design roller conveyors: split profile/bearing point.
- The transport rollers must be individually removable in upward direction.
- Rollers with easily accessible and individually adjustable friction must be used; they must be exchangeable within a transport stage (outside friction).
- The individual frictions must be individually replaceable without removing a transport section (outside friction)
- In all places where workpieces are manually taken off or fed in, it must be ensured that the transport rollers are continuous. To protect the rollers, insertion aids and cover plates must be provided at these locations.
- Design of the transport rollers in finishing steel/plastic only following consultation with production and planning
- Steel rollers must be hardened and ground.
- Plastic rollers with approx. 85 Shore A hardness and high notching impact strength.
- Accuracy measured over 3 rollers max. ± 0.1 mm height offset
- Drive type: wrap chain, toothed belt or bevel gears

7.4.3.1 Accumulating roller chain

- Easily accessible, automatic clamping fixtures must be capable of compensating for changes in length during operation.
- The upper run must be tensed when driven (no coasting)
- The chain guide must be designed with interchangeable running guides.
- The risk of the chain being jammed by small parts (screws, pins, valve parts, etc.), must be prevented using cover clips on the connecting links, where necessary.

7.4.3.2 Plastic chains

Individual elements (links) must be exchangeable. Automatic tensioning devices must be available.

7.4.4 Belt transport

The belt must be guided via guide pulleys at the deflection points.

7.4.5 Workpiece carriers

- The following components must be designed as low-wear and easy to replace:
  Running surfaces, stopper blocks, workpiece supports, indexing units, rollers and support rollers, guide rails.
- The workpiece carriers must be permanently marked with easily readable signs, numbering, e.g., with numbers.

7.4.6 Tilting and rotating stations

- If drives for tilting and rotating stations need to be arranged in the wet zone, the design must use hydraulics.
- The tilting and rotating stations must be provided with adjustable fixed stops.
- If a tilting and rotating station is arranged between two lifting or sliding transports, the workpieces must be positively held.
- There must be advance and return locks in the tilting and rotation stations
- The electric drives on the tilting and rotating stations must be frequency controlled.

7.4.7 Rotary indexing table

- The maximum permissible speed values and loads must be indicated (acceleration and top speed) for all rotary tables.
- It must be possible for 1 employee to complete oil filling and check the fill level (for example, in transfer lines place the sight glass and filler neck on the outside).
- It is important to ensure that as few rotary indexing table types as possible are used (see list of preferred components).
- Rotary and indexing tables must not have a friction clutch.
- Media feed through the rotary indexing table is only permitted with a separate rotary distributor.

7.5 Robots

Robot systems must be selected according to the list and of preferred components and agreed upon with the department. The minimum equipment of the systems must be supplied. The selection of the robot type is based on the non-exhaustive list of parameters:

- Hand load incl. restrictions on permissible moments of inertia and center of gravity position
- Upper arm load
- Ability to reach all operating points in terms of position and orientation
- Control functions
- Trajectory planning

The delivery of the robot system must be in accordance with DIN EN ISO 10218 and additional documents. The requirements of DIN ISO/TS 15066 must be taken into account for collaborative industrial robot systems and their working environments.

The robot tool joint and the tool design must be coordinated with the departments.

The robot flange must always be implemented as per ISO 9409-1.

The robot control system and its additional hardware and software modules must also suit the use case.

It must be possible for Nidec employees to adjust the robot axes with a suitable tool.

When planning and selecting the robots, all operating points, the required articulation positions, easy motion types WITHOUT reorientation and avoiding singularity positions must be verified,

and the system optimized based on the results. Typical reserves must be designed for in all motions.

7.5.1 System integration

The mechanical system must always be secured on a robot base, floor-mounting module or machine plate, so that the existing positioning system can be carried over in case of replacement.

Suitable attachment points on the robots mechanical system facilitate the integration and exchange of robots.

Simple sequence control functions and all time-critical control tasks are performed directly by the robot control system with simultaneous forwarding to the machine PLC. The remaining PLC functions are performed by the parent PLC with forwarding to the robot control.

Profinet is used to communicate with the higher-level PLC.

The robot must be integrated into the safety circuit as a triggering and hazardous system, always using 2 channels. The robot control system does not have a master role.

The dynamic properties of the work system at the flange must be taken into account to optimize motion sequence programming, also for changing loads.

7.5.2 Media supply systems

Internally routed media lines must be given preference.

Media lines plugged into the robot base, wrist, media preparation on the upper arm. Media lines specifically suitable for 3D movements, minimum service life of 2 million load cycles.

Strain relief in the plug area is mandatory.

Always adjust the length of media lines to the application, do not fasten cable loops.

Always fasten strain relief with rubber grommets; fastening with cable ties only is not permissible.

Allow for linear expansion within the media line, fixed side always on the side that is normally above the mating side.

Separate the various media lines within a guide system, but not bundle within the media guide.

Ensuring the observance of processes make sure that minimum radii are observed.

Fill level of a media guide up to 60%; the cables must be able to move internally.

Secure the media guide at both ends, with protectors between the fixing points to prevent jamming on the robot or other devices; the length must be matched for all motion areas and sequences (as short as possible).

7.6 Small material handling/feeding technology

7.6.1 Separators and ordering machines

- The panels on separators and order machines must be resilient to the coating materials of the components to be installed and the components themselves.
- The panels and their adhesives must not react with any cleaning agents.
- Magnetic bodies must be protected against dust and foreign matter.
- Separators, guides and chicanes must be designed to be dimensionally stable and wear-free. A screw separator must be installed upstream of the screw handover. Only raking separators (displacement) must be used for bolts, no rotary separators.

- Transitions between ordering machines and linear conveyors must be screwable and adjustable.
- Component feeds must be provided with openings for targeted dirt removal. The dirt must be collected in suitable, removable containers.
- Overfill protection must be implemented in ordering machines. In the case of overfilling, the ordering machine must switch off and report the overfill.
- Separators must not be damaged by excessively long or short components, or other reject components.
- Component feeders and separators must be arranged to allow easy access for maintenance and repair work.
- An easy removal option for jammed components must be provided. Depending on the design, holding options must be provided.
- Ordering machines must be sealed with covers.
- Filling funnels (deflectors) are required for filling the ordering machines. No bulk material must drop in the area next to the ordering machines.

7.6.2 Vacuum assembly technology and handling

- If ejectors are used, one ejector must be used per suction tool.
- On the suction side, easily exchangeable filter elements must be used between the vacuum generators and the suction tool.
- The line lengths between the vacuum generator and the suction tool must be as short as possible.
- If hoses are used, flexibility and bend free routing must be taken into account (see also HQ-G-C4-08).
- After each work cycle, a blow-out function must be provided on the suction side (cleaning of hoses and suction tools).
- Suction tools must be sensed by electric vacuum switches.

7.7 Cable drag chains

- Use symmetrical from the outside (large diameter) towards the inside (small diameter).
- Strain relief at both ends. Hoses through bulkhead fittings.
- The hoses/lines must be separated (dividers).
- Hoses/lines must not cross when dragged beyond the stress relief.
- Hoses/lines must not be routed through multiple chains.
- The drag chains must be guided in parallel an all levels.
- Sliding blocks may only be omitted following consultation.
- Upwards chain loops must be avoided.
- It must be possible to open and individually exchange chain links.
- Cables must be exchangeable without removing the connector.
- Observe the minimum radius and assembly guidelines (twist free) of dragged cables as per the manufacturer's instructions.
- Cable ties must not be used in protective hoses/energy supply chains.
- All components must be clearly marked (order number, type).
- If rotary distributors are used to supply energy, this must be agreed upon with the departments.

7.8 Workpiece clamping devices

- Clean workpiece supports must be guaranteed in a fixed cycle.
- Sufficient lubrication of the jig's functional parts must be ensured.
- Fixing bolts/index, support and contact points must not be designed as threaded screws, but as fits with a locking screw.
- Where the coordinates are important, it must be possible to adjust fixing bolts within the device in any direction using an adapter plate. These fixing bolts must have a predetermined breaking point (to prevent breaking out of the clamping device in the event of an overload).
- The workpiece must be positively held in the intermediate depositing area (by index pins or lateral boundary elements).
- If testing, measuring, or other operations are required in intermediate depositing area, check in each individual case whether the workpiece needs to be held.
- Clamping devices by one manufacturer must be used within one project/scope of delivery (see also preferred components list).
- Where the coordinates are important, it must be possible to adjust fixing bolts within the device in any direction using an adapter plate. Fixing bolts must have a predetermined breaking point (to prevent breaking out of the clamping device in the event of an overload).
- The workpiece must be positively held in the intermediate depositing area (by index pins or lateral boundary elements).
- If testing, measuring, or other operations are required in intermediate depositing area, check in each individual case whether the workpiece needs to be held.

7.9 Handling devices

- In the event of a power outage, it must be ensured that the workpieces in the gripper are safely held mechanically.
- The gripper must be adjusted by means of an adjustment element (horizontal double plate with adjustment screws).

7.10 Noise insulation elements

Only non-flammable materials may be used for noise insulation. *VDI 2711* "Noise protection by encapsulation" stipulates:

- "To protect the absorption material from soiling or falling out, a glass fiber fabric or nonwoven fabric is typically also affixed. To prevent penetration by flammable components (e.g. oil) or moisture, paneling made of noise absorption material with a plastic foil (10-20µm thick) is essential in certain cases; the paneling must be loosely arranged in front of the absorption material. The foil only slightly reduces the absorption of high frequencies".
- The use of insulation materials must be coordinated with the specialist department.
- Artificial mineral fibers that do not meet the criteria of Annex IV No. 22 Hazardous Goods Ordinance (GefStoff V) must not be used. Ceramic additives are not permitted.
- Insulation and noise insulation must be protected by suitable measures against moisture absorption and mechanical damage (see, e.g., sandwich design).

7.11 Exhaust air in the process

An extraction port must be installed above each workplace/station (defined in the project requirement specification). The extraction port vents is included in the machine suppliers' scope of delivery.

The exhaust air must be dimensioned to match the process and take the supply air into account in sufficient detail. The appropriate Nidec specialist department must always be involved in extraction during the construction phase.

7.12 Measuring technology: Mechanical design

The electrical supply cable must be designed to plug into the sensor.

7.12.1 Force measurement

- The installation of the measuring system must be stress-free (floating bearing). Avoid lifting of the measuring element due to excessive backlash.
- Force transducers must not be used in the case of impacting or tapping movements. Suitable overload protection must be provided.
- The force sensor must be selected such that the expected maximum press-in force is within the range of up to 70% of the sensor's nominal value.
- Normalized sensors must be used.
- For the measuring system, a suggestion for a useful verification measuring system has to be presented during design release of the equipment. The force input at the contact surfaces must be parallel, centric and free of lateral forces.

7.12.2 Stroke measurement using measuring probes

- The stroke measurement system must be equipped with end position limiters to avoid mechanical damage to the probe.
- The mounting of the sensor/probe must allow for unambiguous positioning (reducing the overhead for replacing the probe)
- Take appropriate measures to avoid mechanical lifting of the probe (jumping) due to rattling during feed motion.
- Direct measurement of the base surface defined in the drawing must be ensured.

7.12.3 Torque measurement

The measured value must be transferred without slip rings.

Ensure a compact design of the torque transducer with borne shafts.

Normalized sensors must be used.

7.12.4 Measuring systems with a glass scale

Glass scales must be installed for easy access (replacement time max. 2 hrs.).

The type plate must be legible after the glass scale has been installed. A duplicate plate must be provided, if necessary.

The positioning of the glass scale must be repeatable (use of stops to facilitate positioning).

The glass scale must pressurized with sealing (supply of sealing air required).

8 References/applicable documents

The Mechanical System annex must be used as part of the basic requirement specification for operating equipment for Nidec and only in conjunction with the other parts.

The normative references are listed in the basic technical supply agreement document.

9 Special notes

None

10 Changes made since the last publication

First edition with new number