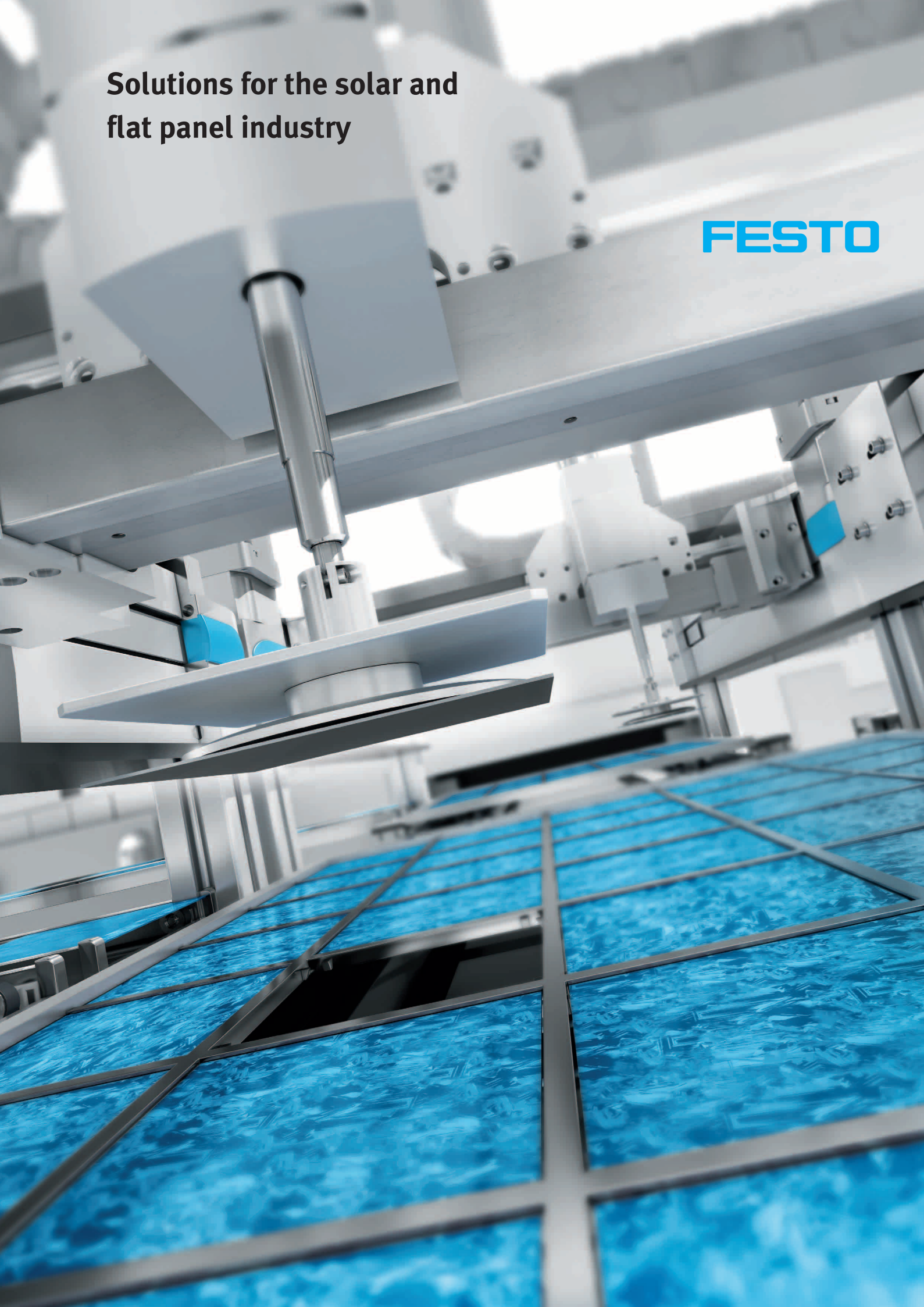
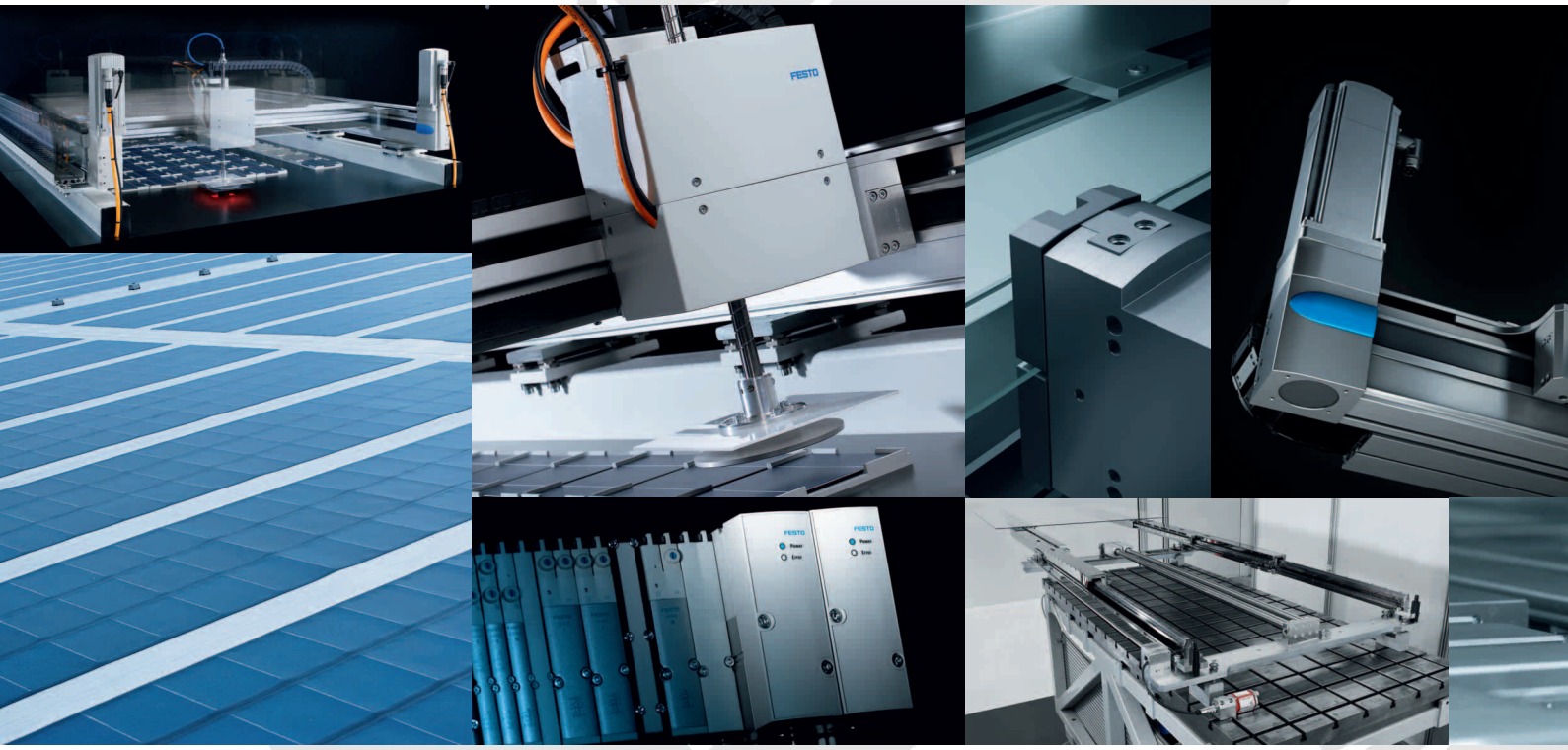
Solutions for the solar and flat panel industry

FESTO





Wafer, thin film, roll-to-roll – intelligent automation exploits the potential to the full

Climate change and dwindling raw materials are prompting a rethink about how energy is generated. As a result, the use of solar energy has increased significantly in recent years, leading to a strong rise in the production of photovoltaic systems. In order to meet the demands of this growing market, machine and system manufacturers are resorting to reliable and innovative automation technology.

The photovoltaic industry is currently divided into two: on the one hand we have the traditional method of producing solar modules on the basis of silicon wafers and on the other hand we have the more recent and very promising area of thin-film technology. Both the wafer-based method for producing solar cells and the method for producing thin-film modules are highly automated.

Festo's product range and solution packages are optimised to meet the challenges of both of these technologies. The range includes drives that can also work in a vacuum as well as optimised gripping technology and complete handling solutions for transporting modules.

Target: grid parity
As a young, dynamic and innovative industry, the photovoltaic industry is constantly evolving. It is our task to supply optimum automation solutions from a single source that offer greater benefits across the entire value added chain. For example, ready-to-install products and services from Festo reduce the total cost of ownership and at the same time lower production costs. Or innovative concepts and solutions that can be used, amongst others, for up-and-coming trends such as roll-to-roll production. Festo is actively shaping this future and also helping to bring the major target of grid parity one step closer.

Your applikation is our focus

Festo – your partner in photovoltaics for the entire automation process chain. Whether your production is focussed on:

- Producing wafers or thin-film cells
- Manufacturing cells or modules
- “Inline” or “batch” production

Festo optimises the automation solutions to meet your requirements in order to integrate them in your production as seamlessly as possible. Tell us what you need. And we will develop an individual solution for you.

Solution competence: more than just products
Festo offers services for the entire life cycle of complete system solutions. These range from consulting and engineering complete handling solutions through commissioning ready-to-install systems to an extensive after sales service. They go hand-in-hand with a fast return on investment, maximum productivity and increased process reliability – a set of benefits that pays off.

The suitable hardware is available to you from the multi-axis modular system without restrictions or interface problems, even for very complex handling solutions:

- Simple pick and place handling units
- Linear gantries
- Three-dimensional gantries
- The premium class: optimised, high-speed handling systems

Festo designs the complete system solution according to your specifications and takes care of testing and commissioning. And then integrates the complete solution (including the suitable control architecture) in your communication concept and your control system.

Talk to our specialists.

Wafer-based solar module production

The road from quartz sand to a completed solar module is a long one. The first step is producing ultra-pure silicon that is cast under extreme temperatures into what is referred to as an ingot. This ingot is washed, treated and cut into slices, producing the wafer. After being coated a number of times and equipped with contacts, the end product is the finished solar cell that is soldered with numerous other cells and assembled as a module.

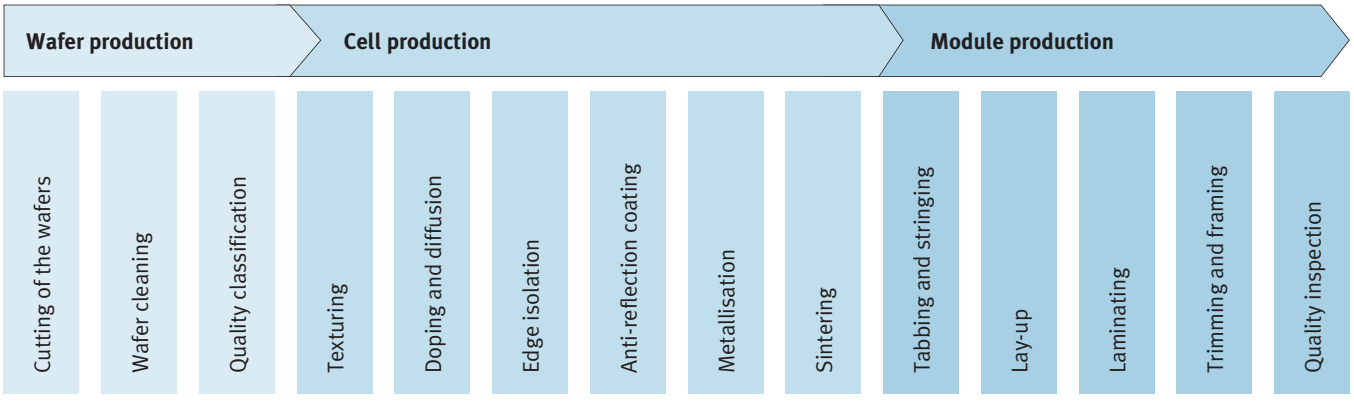
Within this long process, the individual production steps pose very different challenges. Festo supports the optimisation of these production steps across the entire process chain.

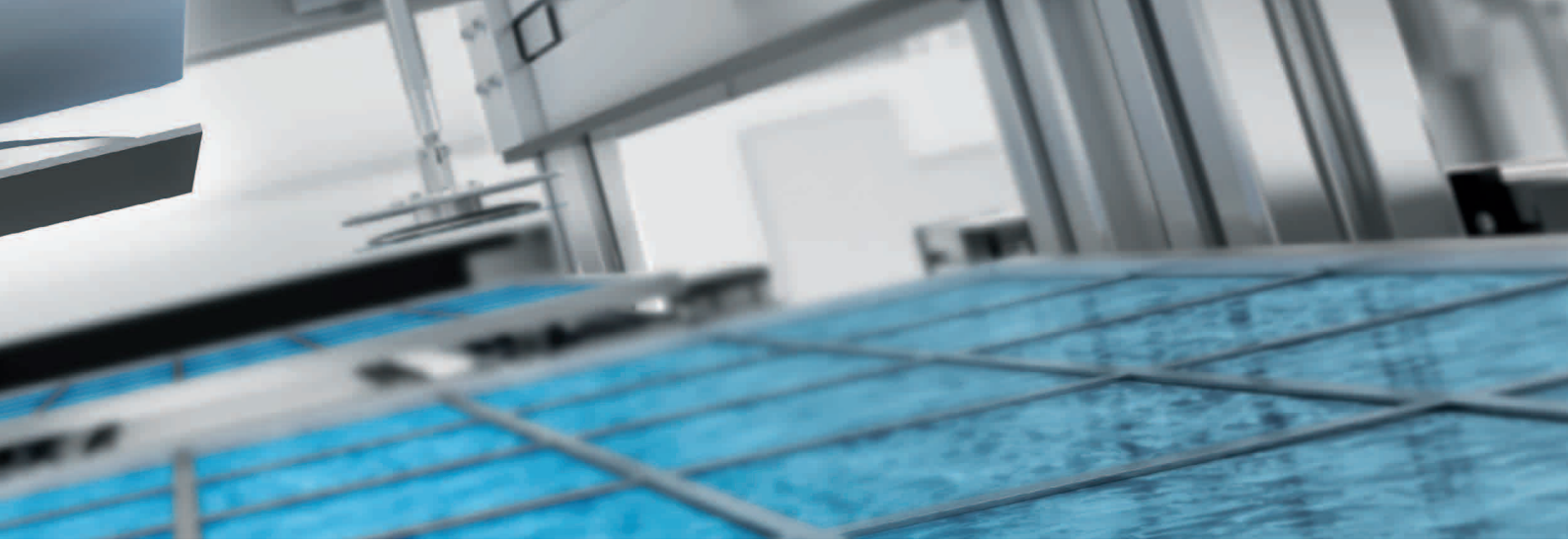
Reducing the breakage rate and increasing the throughput
These are the main targets of solar cell manufacturers. To achieve the optimum combination of sturdiness and an attractive price, the thickness of the wafers is therefore also constantly changing.

That is why the requirements for transporting and handling the wafers are so high. Reduced breakage rates and increased process reliability can be achieved with innovative handling solutions and the latest gripping technologies.

Integrated quality inspection
There is nothing more expensive than transporting rejects through the entire production process, turning them into the end product and receiving a complaint from the end customer after it has been delivered. Vision systems optimised for the characteristics of the wafers perform this task with ease and can also be seamlessly integrated in the complete solution.

Sophisticated module production
The ready produced solar cells are combined to form strings and modules. A sensitive process in which specially developed handling and gripping systems from Festo's modular system are used to fully automate this module production procedure.





Gentle and reliable gripping

Application
During the production process, the wafers have to be constantly and reliably picked up and transported through the various production steps. This demands high speed in order to keep the production costs of the modules as low as possible. However, gentle handling is also required as the wafers must not break.

Challenge
The further the wafer production process progresses, the more refined the wafer is and the more valuable it becomes. Suitable gripper technology at the right moment is therefore essential for workpiece handling as well as for reduced investment and energy costs for the machines.

Solution option 1: Gripping with vacuum suction insert
The suction insert OASI provides protection against the suction and destruction of the fragile workpieces. In combination with the suitable vacuum suction cup and vacuum generator, this is a complete solution for reliably picking up and checking the wafers. This low-cost solution is ideally suited to handling raw wafers, for example for a loading station at the beginning of a cell production line.

Advantages
- An increased contact surface area prevents the suction of fragile workpieces
- Stops the valve becoming dirty
- Reduces investment and energy costs

Solution option 2: Gripping with Bernoulli suction cups
Shadows on the wafer reduce the performance of the finished solar cell. These shadows are often the result of residue left on the surface of the wafer after gripping. The Bernoulli suction cup picks up the wafers with almost no contact and repositions them reliably. In contrast to vacuum suction cups, the Bernoulli suction cup works with pure compressed air. This is forced outwards by means of a tiny, ring-shaped gap, thus generating a suction effect that enables the wafer to be lifted gently, but safely – without leaving any residue on the wafer. Inserts of stainless steel, polymer, PEEK or aluminium are optionally available, depending on the application.

Advantages
- No vacuum needed at the gripper
- Reliable and stress-free transport
- Contactless – no residue on the surface

Reliable pick-up of the wafers with the OASI suction insert

Contactless gripping of the wafers with Bernoulli suction cups

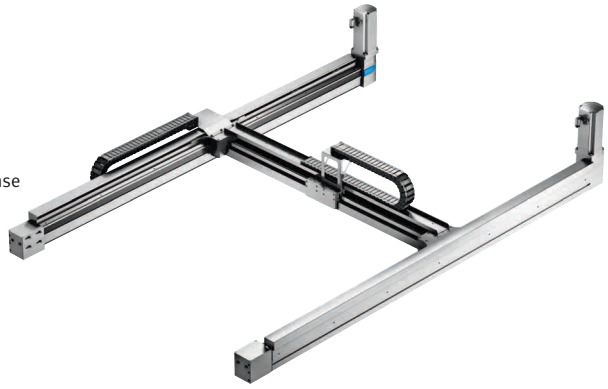
Fast and reliable repositioning: high-speed H-gantry

Application
The fragile wafers often have to be repositioned. During the transition from one production step to the next, they are unloaded from one machine and conveyed to another. To maximise the output this has to be done at maximum speed, but at the same time safely and precisely. The fragile wafers often break due to the high speed of the individual production steps. This causes significant downtimes and a greater need for quality control: each time a wafer is loaded and unloaded, it is checked to make sure it is intact.

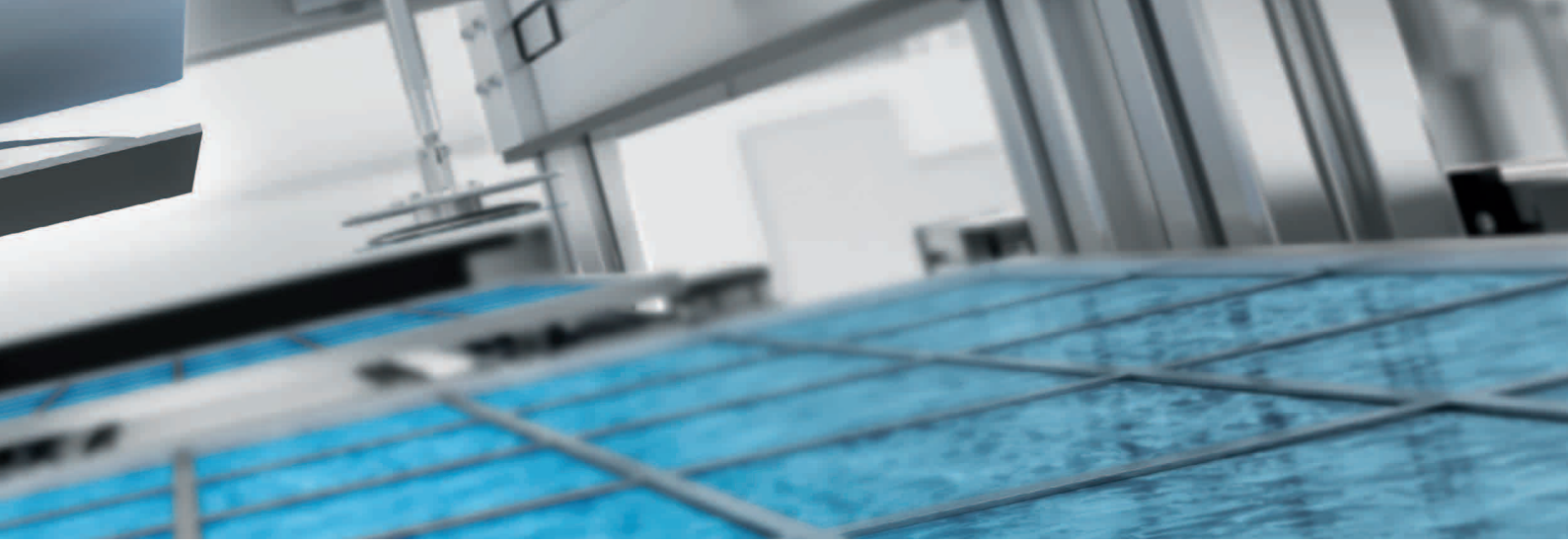
Challenge
A system for transporting wafers has to be smooth, quick and reliable. Contact should be as gentle as possible so as not to stress the wafers. No residue must remain on the their photosensitive surface if best use is to be made of the light. In addition, the wafers are checked for intactness very frequently. These checks must be as short as possible to keep up the throughput.

Solution
The high-speed H-gantry is optimised for handling solar cells and wafers. It covers a rectangular working area with up to four degrees of freedom. A rotary lifting module that provides the movement of the Z-axis and the rotary movement picks up and repositions the wafers. The Bernoulli suction cup enables almost contactless and gentle transport and is therefore ideally suited to transporting the fragile wafers. The optionally integrated camera checks the wafers for breakage or incorrect alignment.

The H-gantry is distinguished by its flat design and high dynamic response



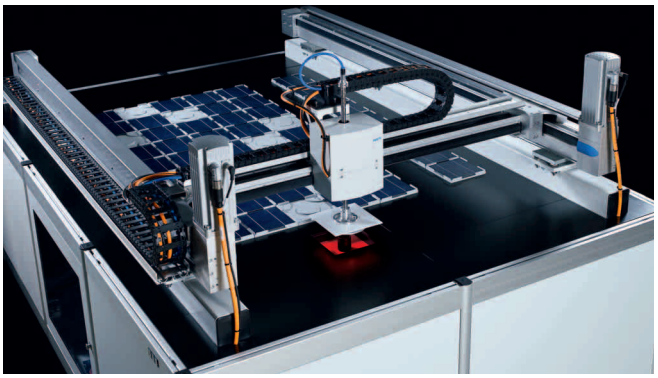
Winner of the Intersolar award



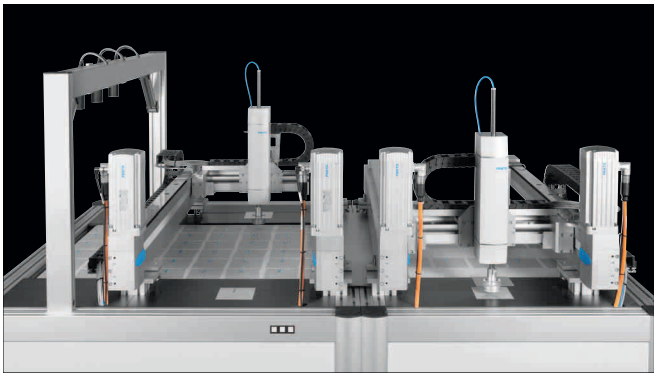
Advantages

- Scaling the output: the intelligent mechanical and control-specific combination of two gantries enables the throughput to be increased up to 6000 wafers per hour
- Exceptionally dynamic in the most compact of spaces: the combination of flat design and low moving mass
- Twice as good: combines the working space of a Cartesian gantry with the dynamic response of a kinematic system
- High dynamic response in space: the stationary motors and the resulting low moving mass achieve 50 m/s^2
- Covers twice the working space of kinematic systems with the same throughput
- Reduced breakage rates: minimal overswing during positioning thanks to independent degrees of freedom
- Improved acceleration and braking behaviour: for strokes along the X-axis and Y-axis from two to one metre with repetition accuracy of 0.08 mm
- Reduced production costs: costs can be lowered by up to 30% compared with kinematic systems

Additional information can be found in the “Advanced Handling” brochure



Combined with Bernoulli suction cups and an integrated camera, the high-speed H-gantry is an optimum handling solution for transporting solar cells and wafers



The combination of two H-gantries enables the throughput to be increased up to 6000 wafers per hour

Quality inspection and position sensing: intelligent vision systems

Application
The extreme fragility of the wafers means that they are frequently damaged during production or transport. To detect cracked wafers as quickly as possible and remove them from the process, a continuous quality inspection takes place. In addition to the quality inspection, position sensing (e.g. when loading trays and cartridges) also plays an important role in keeping the breakage rate low.

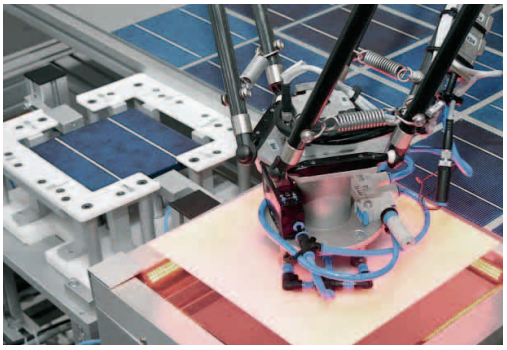
Challenge
To keep lost time to a minimum, the quality inspection is performed on-the-fly while the wafers are being transported to the next production process. At the same time, the alignment of the wafers is sensed and if necessary corrected.

A quick and reliable quality inspection lowers production costs, increases production reliability and improves competitiveness – as well as going a long way towards the target of grid parity.

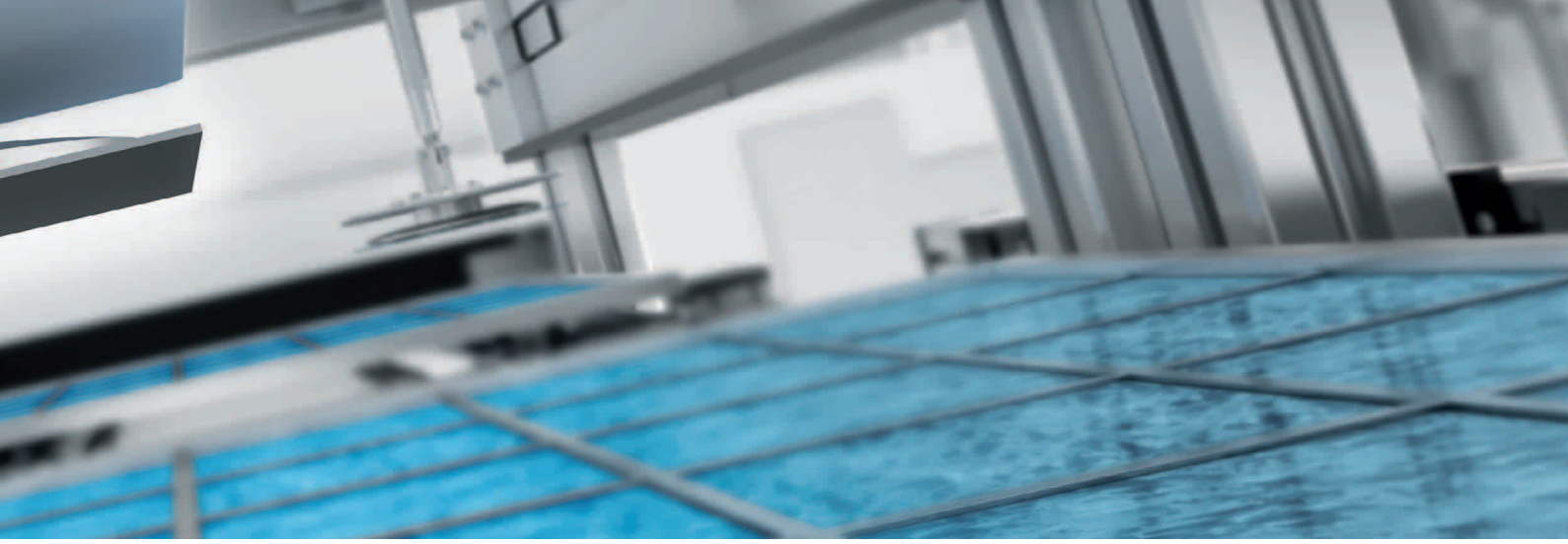
Solution
A handling system removes a solar wafer from the stacking magazine. When moving it to the deposit position, it passes the inspection station at 1 m/s. The compact vision system SBO...-Q senses the position of the wafer in relation to the gripper during the movement and also checks the edges and corners for cracks exceeding 1 mm. The inspection is performed on-the-fly without stopping. Wafers of good quality are placed in correct orientation at the target position, bad wafers are ejected.

Advantages
- No interface problems: standardised software interfaces via Ethernet (TCP/IP, EasyIP, Telnet, ModbusTCP) as well as integrated 24 V I/Os
- Easy commissioning thanks to user-friendly software
- Optional: CANopen master functionality in combination with CoDeSys 2.3 embedded
- Various sensor resolutions, monochrome and colour: 640 x 480, 752 x 480 and 1280 x 1024 pixels
- Compact dimensions, low weight

Quality inspection and position sensing: these are the strengths of the intelligent compact camera SBOQ



The quality inspection is conducted “on-the-fly” without stopping



Lay-up station

Application
After the solar cells are connected and contacted in the tabber and stringer, the lay-up station automatically positions the strings on the glass plates covered with an EVA film. The strings are manually or automatically soldered at the next station for cross wiring. The cells are then laminated.

Challenge
To make the best possible use of the surface of the glass module, the strings must be aligned exactly parallel to each other at the smallest possible distance. For subsequent cross wiring of the strings, every second string must be turned 180° before it is placed on the glass. The movement must be as gentle as possible so that no cells are broken. This is important as the cells are not inspected again before the lamination process.

Solution
An electric linear gantry masters this task with ease. Toothed belt axes EGC with sinusoidal acceleration ramps ensure jerk-free movement when picking up the strings. A servo motorturns them and positions them precisely. The mechanical structure of the electric axes makes the gantry and its movement very sturdy.

Advantages:
- Sinusoidal acceleration ramps for gentle and jerk-free movement
- Strings are turned by a servo motor
- Absolutely reliable transport – even of extremely sensitive cells with different manufacturer specifications

An electric linear gantry positions the strings as gently as possible to prevent cell breakage

The toothed belt axis EGC with sinusoidal acceleration ramps ensures jerk-free movement when picking up the strings

Thin-film-based solar module production

With thin-film technology, ultra-pure gaseous silicon is applied to glass to make more economical use of the precious ultra-pure silicon.

At the beginning of the process the glass substrate is cleaned, inspected and placed in the load lock by a robot. The load lock transports the glass substrate into the process machine. The heated glass is then channelled into the first CVD process system, where it is coated, for example, with silicon.

Its surface is then structured with lasers, creating the P-N transitions required to generate electricity.

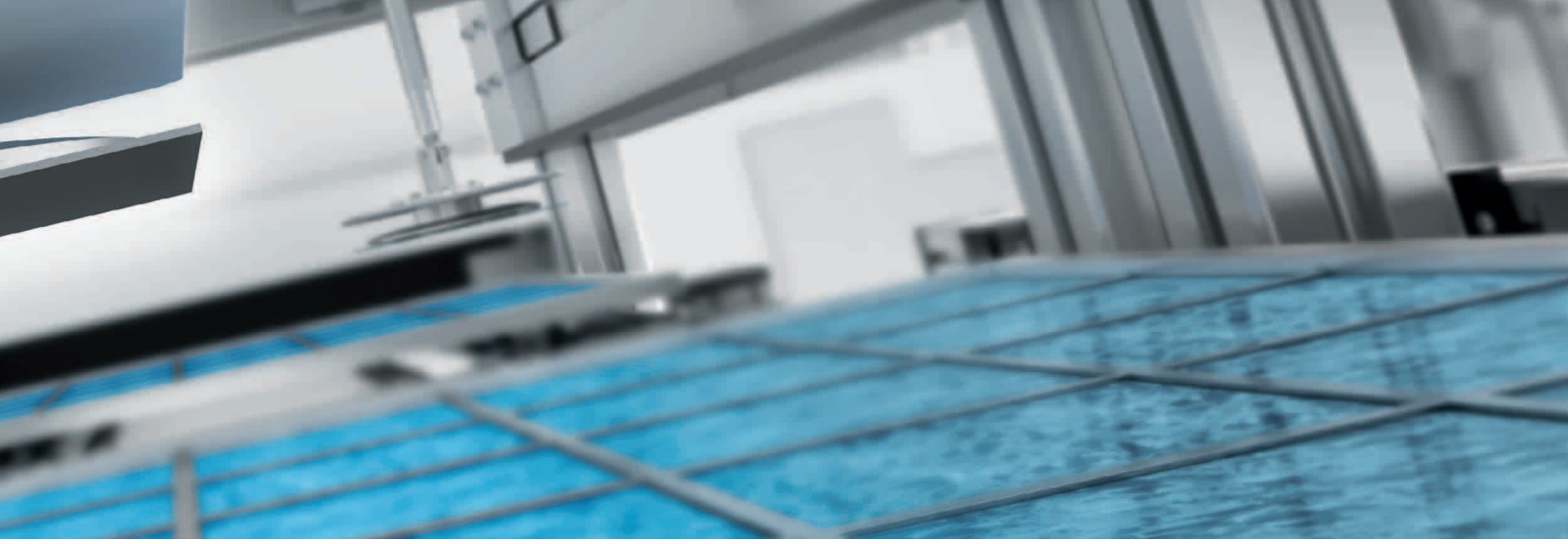
Very different processes – perfectly adapted solutions
Perfectly adapted solutions greatly improve the output and at the same time reduce the rejects to a minimum. Festo accompanies you and supports the optimisation of your production process in all its facets.

Special handling systems
The glass to be coated is channelled via load locks into CVD process systems, where the thin-film coatings are applied. The fragile glass substrate is transported from one process chamber to the next by means of special handling systems. The ambient conditions are critical here: high vacuum and temperatures up to 200 °C are challenging for the handling system.

Air-bearing table for dynamic processing
Once the glass has been coated with silicon, it is structured with a laser. It must be guided quickly and precisely through the laser. Air-bearing tables are the ideal solution for controllable, contactless handling.

Gentle repositioning
Vertical repositioning of the big and heavy glass modules is accomplished reliably and precisely by lifters. Based on electric axes, they reposition the glass plates safely and gently.

Precise bonding procedure
The thin-film cell is equipped with contacts at the end of the production process. The adhesive beading should be as even as possible. The controlled movement of the adhesive heads, two independent dispensing heads, is critical here.



Laser structuring on air-bearing rails

Application
In order for solar modules to achieve maximum possible efficiency, the maximum possible voltage must be achieved. That is why the coated glass plate is divided into numerous individual areas. These are then connected in series. The plate is structured after the coating operations: the coated glass is guided through the laser by a handling system to create the laser scribes.

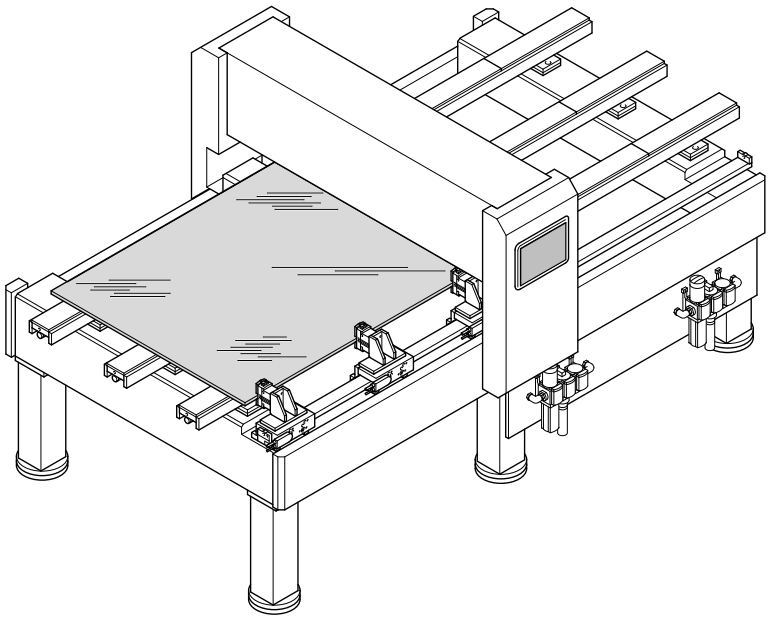
Challenge
The requirements for the linear transport of the coated glass are extremely high: on the one hand, the position of the individual lines only permits very small tolerances. However, the long lengths of the modules and the mass to be moved, in some cases of over 100 kg, also represent a challenge.

This creates high costs for the manufacture, transport and production as the speed of the movement is limited, but the energy consumption is still high. The trend towards further increasing the module formats exacerbates this problem.

Solution
Air bearings are revolutionising this process. The coated glass is moved into a floating position by an air cushion. Air-cushioned linear motor axes with parallel grippers guide the coated glass gently and precisely through the laser.

This design principle enables higher speeds to be achieved with ease, resulting in a higher machine output. The integrated air gap sensor SOPA monitors the flying height of the glass throughout the entire lasering procedure and in this way optimises the energy consumption of the air bearings.

Advantages:
- Guaranteed accuracy: very exact lasering scribing thanks to the low-vibration and precise linear motor movements
- Low-vibration movement thanks to the low moving mass
- Straightforward assembly and adjustment by means of air-bearing rails: no alignment of individual air bearings
- Higher throughput thanks to increased speeds
- Optimised for the respective application: the entire system is designed by Festo

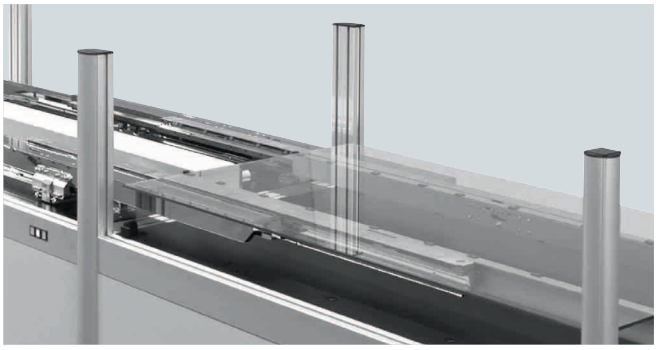


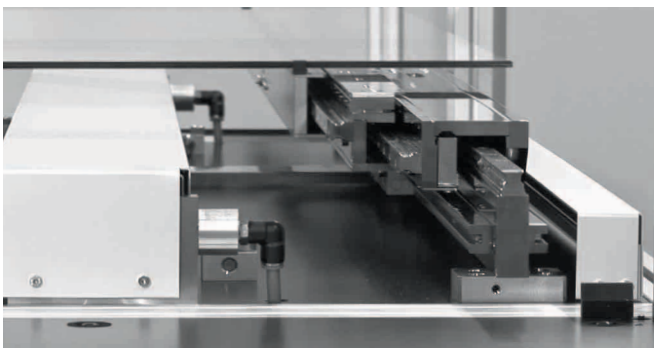
Loading and unloading glass substrates: sliding fork

Application
Glass with a thickness of four mm is fed into different process chambers and coated during the production of thin-film solar cells at the front end. This process area is under high vacuum and at a temperature of approx. 200 °C. Special clean room robots are traditionally used to transport the coated glass plates from one process chamber to the next.

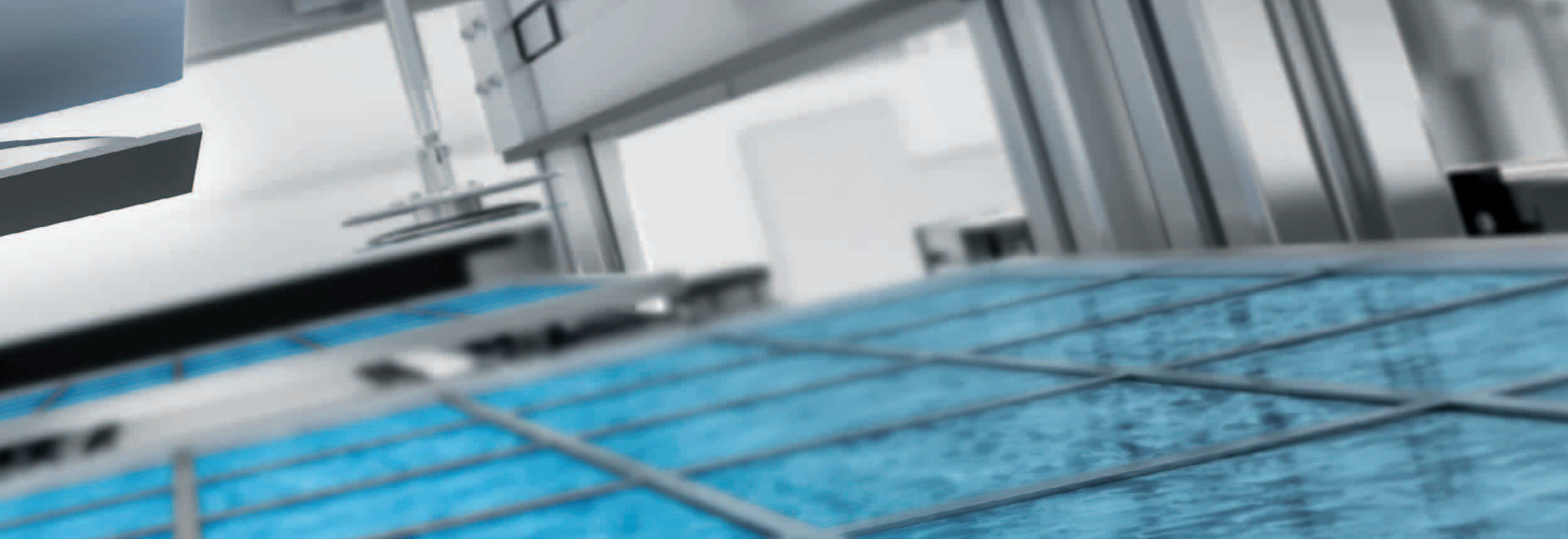
Challenge
Lowering production costs, while meeting very exacting requirements for the process. The high ambient temperatures in the clean room place highest demands on the application. Conventional pneumatics cannot be used due to leakages at high vacuum. In addition, the system should be as compact as possible with the process chambers opposite each other for short transport distances. With this linear arrangement, is easy to add further process modules to the system.

Solution
The infinitely variable telescopic handling system “sliding fork” is ideally designed for this process. Developed for use in high vacuum areas, it can cope with the high temperatures.



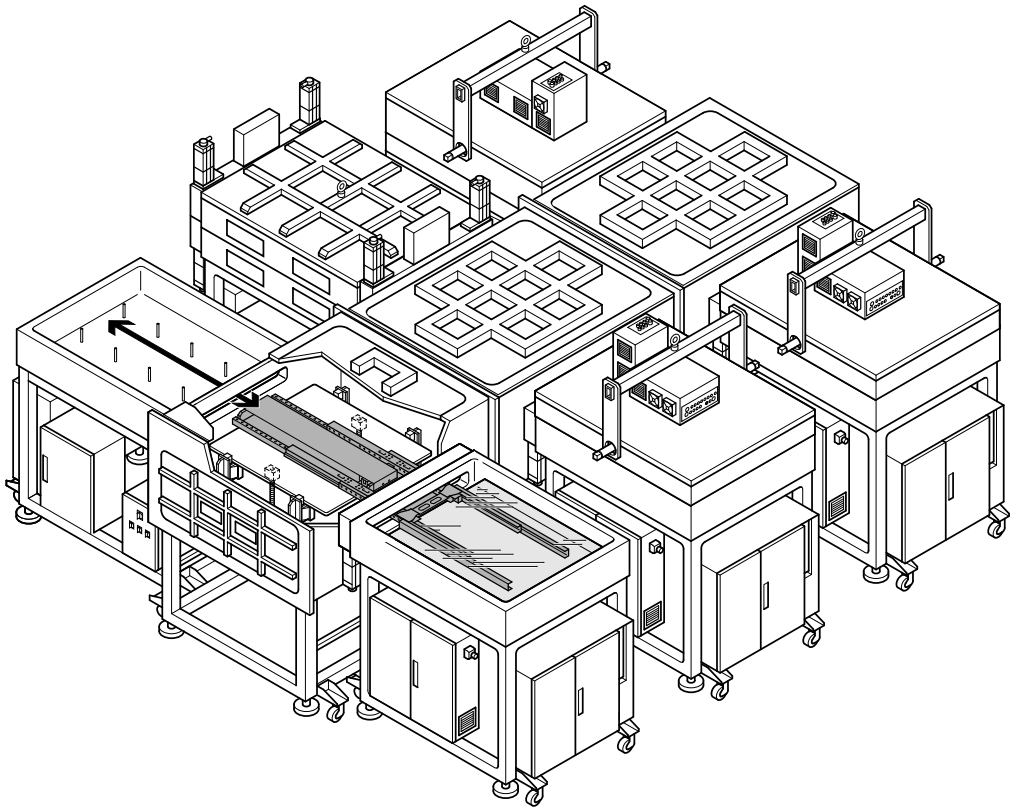


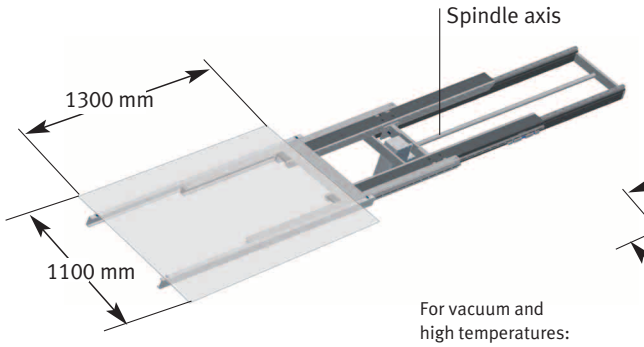
The infinitely variable telescopic handling sliding fork is ideal for use in high vacuums.



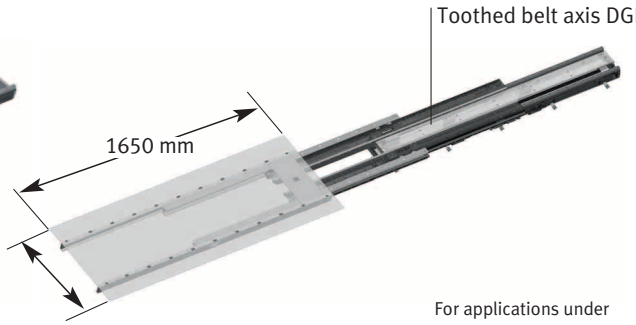
Advantages:

- Installation space = workpiece size
- More cost-effective than robot solutions
- Extension at both ends with infinitely adjustable intermediate stops
- Stroke of up to 2 m: telescopic principle with triple transmission ratio
- Reduces the installation space and prevents leakages: rodless cylinder with magnetic force transmission
- Selectable drive modes depending on the application: spindle axis for high vacuum or toothed belt axis for applications in atmospheric conditions





For vacuum and high temperatures: electric spindle axis



For applications under atmospheric pressure: electric toothed belt axis

Gentle and careful: lifter

Application
The individual production steps for the thin-film modules are often not precisely linked. To get from one production step to the next one, the fragile glass plates have to be transported in a vertical position and repositioned.

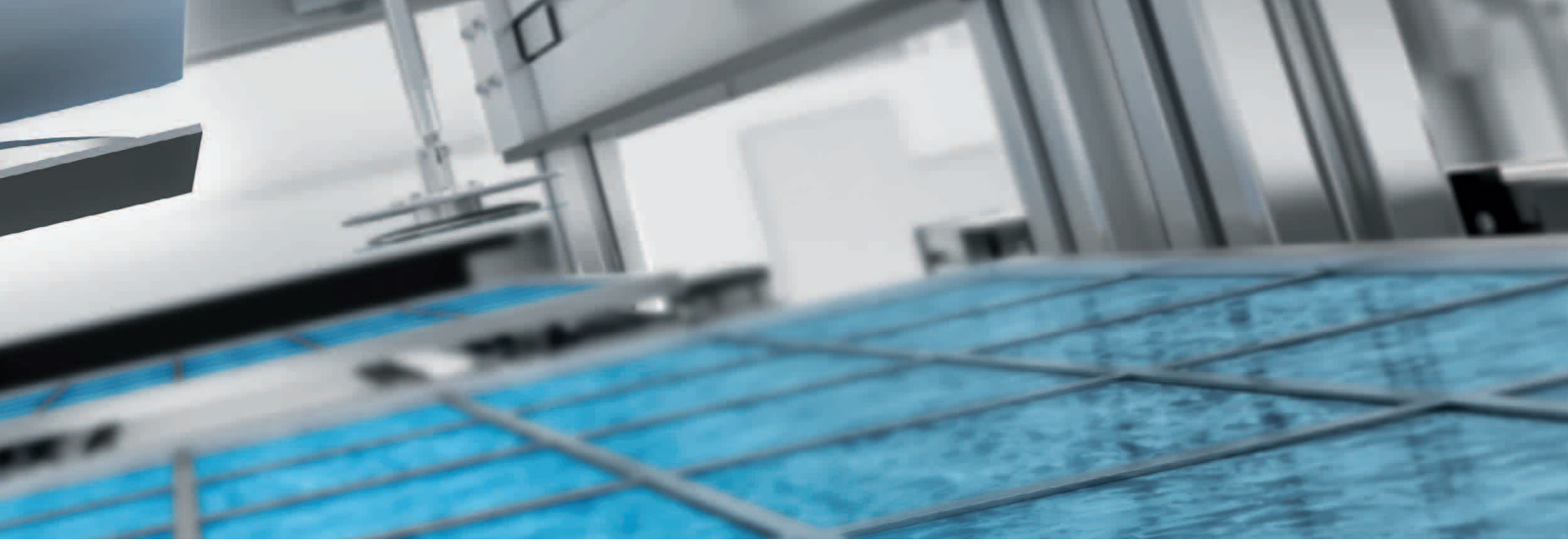
This repositioning must be done as gently as possible to avoid breaking the plates. The glass plates roll on a workpiece carrier developed specially for this purpose and that is lifted together with the glass. The entire moving mass is very heavy, which is why special vertical handling systems are used.

Challenge
Heavy weight, maximum speed, even and gentle movement: these three requirements must be met. Classic spindle solutions often reach their limits because of the high moving mass of the heavy glass plates.

Solution
The ingenious combination of pneumatic and electric drives uses the advantages of both technologies. The pneumatic axis balances the weight, while the electric axis with toothed belt drive controls the movement. This ensures the glass is positioned quickly, but at the same time gently.

Advantages:
- Advantages of both technologies from a single source optimise the behaviour during transport
- Combination of two technologies
- Slim design thanks to space-saving components
- Significant reduction of the motor and controller sizes compared to spindle solutions

Pneumatic and electric drives are cleverly combined in Festo lifter systems and thus ensure gentle positioning of the glass



Precise and fast: dispenser

Application
In order to utilise the energy obtained with the thin-film cell, they are equipped with contact bands that dissipate the electricity produced. First, a handling system at the back end of the process applies adhesive to the coated and structured thin-film module. During the bonding procedure, also called dispensing, it is crucial that the adhevise beads are applied quickly and evenly.

Challenge
Precision is required to apply the adhesive track: the application of insufficient conductive adhesive will not guarantee sufficient contact, too much adhesive can result in short circuits. Speed is also an important issue for competitive production. The application must also be able to deal flexibly with the varying glass formats.

Solution
Two dispensing heads that work in parallel and can be positioned independently of each other apply the adhesive beads to the thin-film cell. Thanks to the precision of the axes, the adhesive beads are accurate to within 0.2 millimetres.

Advantages:
- Track length, track spacing and formulas etc. can be programmed as desired. All programs can be stored and called up at any time
- Exact and precise: the two dispensing heads working in parallel can be positioned by means of independent X-axes
- Space-saving integration: the motor, gear unit and controller from Festo as well as power electronics with positioning control are integrated in the drive of the two electromechanical linear axes DGE. No space required in the control cabinet and no complicated cabling needed anymore
- Easy to install because two cables are sufficient for the installation of the motor MTR-DCI: one for the power supply and one Profibus cable. The commissioning process can be performed directly on the MTR-DCI via the LCD display or in the the FCT (Festo Configuration Tool) on the PC

Two dispensing heads that work in parallel and can be positioned independently of each other apply the adhesive beads to the thin-film cell

Production of flat panel

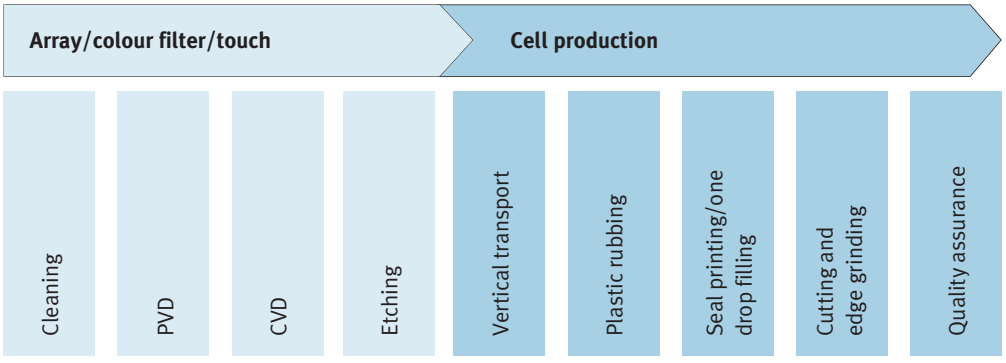
Quick, gentle, reliable and precise: these attributes characterise economic production of flat panels. The quality of the flat panels depends on the cleaning of the glass plate prior to coating, the application of semiconductor layers by means of CVD and PVD processes as well as the etching of the substrate.

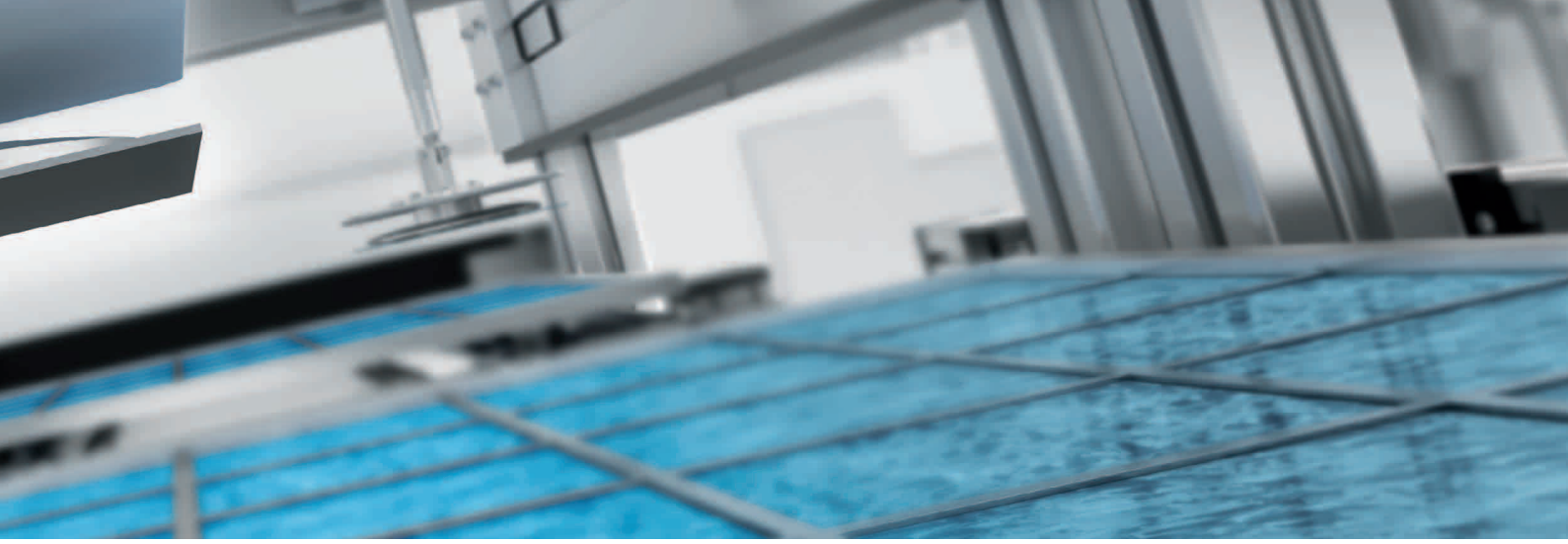
The cell production is the second process area in which the finish is applied to the screen in several stages. Regardless of whether for plastic rubbing, seal printing, separating or grinding the edges, there are interesting products and solutions from Festo which meet the customer-specific requirements for each of these process steps.

Actuating process valves safely and reliably
Absolutely reliable pilot control of the process valves, e.g. with the valve terminal VTOC, is required for numerous front-end applications. Redundant actuation via all conventional fieldbus systems and optionally via hardware interlock connections makes them particularly reliable and ideally suitable for gas box applications.

Contactless transport on air-bearing tables
The glass substrates are transported on air bearings virtually without contact. Special suction cups hold the glass in suspension without leaving any residue, while electric drives control the movement in alignment stations and rotary tables. Festo provides complete solutions from a single source – with an integrated diagnostic module, which, among other things, controls the air consumption and makes the application as energy-efficient as possible.

Gentle lifting of great masses
Festo lifter systems are interesting whenever a heavy weight has to be positioned at maximum speed. The ingenious combination of pneumatic and electric drives uses the advantages of both technologies: the pneumatic axis balances the weight, while the electric axis with toothed belt drive controls the movement. This ensures that the glass is transported quickly, but at the same time gently. The customised solutions are optimally configured by a design software which also takes in to account the operating costs.





Contactless transport on air-bearing rails

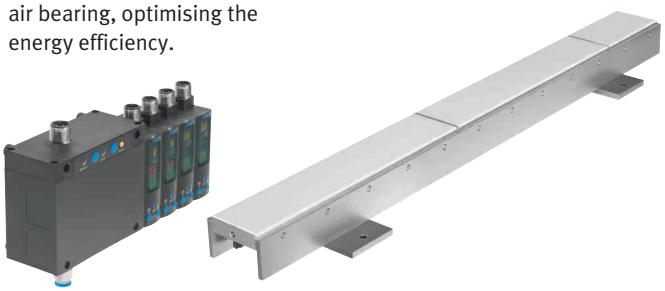
Application
The glass substrates have to be transported gently, reliably and quickly over long distances throughout the entire production process.

Challenge
For cost reasons the plates are usually transported on rollers. However, on the one hand they limit the transport speed and, on the other hand, particles are released which reduce the quality of subsequent processes. Contactless transport by means of air bearings is ideal to avoid these limitations. Alignment stations and rotary tables can also be implemented with air bearings which makes it a great deal easier to set up these stations. As a result, the glass substrates slide through the production process with as little contact as possible.

Solution
Air-bearing rails work like an air cushion. The glass substrates coated on both sides are transported through the process on air bearings without contact. Electric drives with special suction cups move them through the process. The suction cups do not leave any residue on the surface of the glass.

To keep the energy consumption as low as possible, the air consumption is controlled by a service unit with integrated diagnostics. The air gap sensor SOPA measures the exact distance between the glass and the air bearing, optimising the energy efficiency.

Advantages:
- Virtually contactless handling of the glass substrates
- Complete solution from a single source – with integrated diagnostic module, which controls, among other things, the air consumption and makes the application as energy-efficient as possible
- Optimised suction cups – no residue on the thin-film module at all



The glass substrates are transported on air bearings virtually without contact, which can be installed to form customised rails.

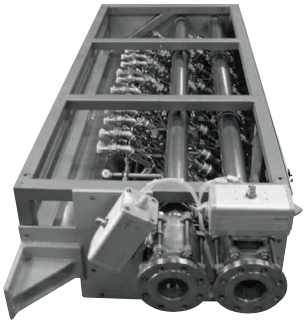
Ready-to-install cooling water distribution

Application
The energy for the sputter deposition in the PVD process for the production of LCD screens is supplied by means of cathodes which have to be cooled. Conventional solutions usually perform this secondary process outside the machine. The pre-installed and pre-assembled solution from Festo can be integrated in the system thanks to Customised Engineering.

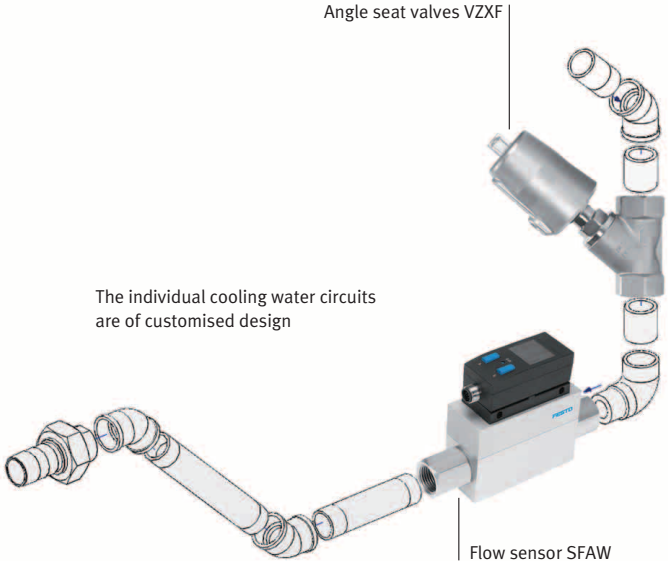
Challenge
The aim is to develop innovative customised solutions which are available worldwide. Furthermore, the focus is on quick implementation of the solution as the short development and innovation cycles of the industry are short. A particularly clever solution for the cooling water distributor is its flexible and modular structure which allows it to be used for different types of systems. It is also very compact and therefore saves valuable space in the clean room.

Solution
Festo Engineering works hand in hand with the development departments of the client to ensure quick implementation. Everything comes from a single source: the engineering, the assembly and the almost exclusive use of Festo products guarantee a quick implementation of the ready-to-install cooling water distribution.

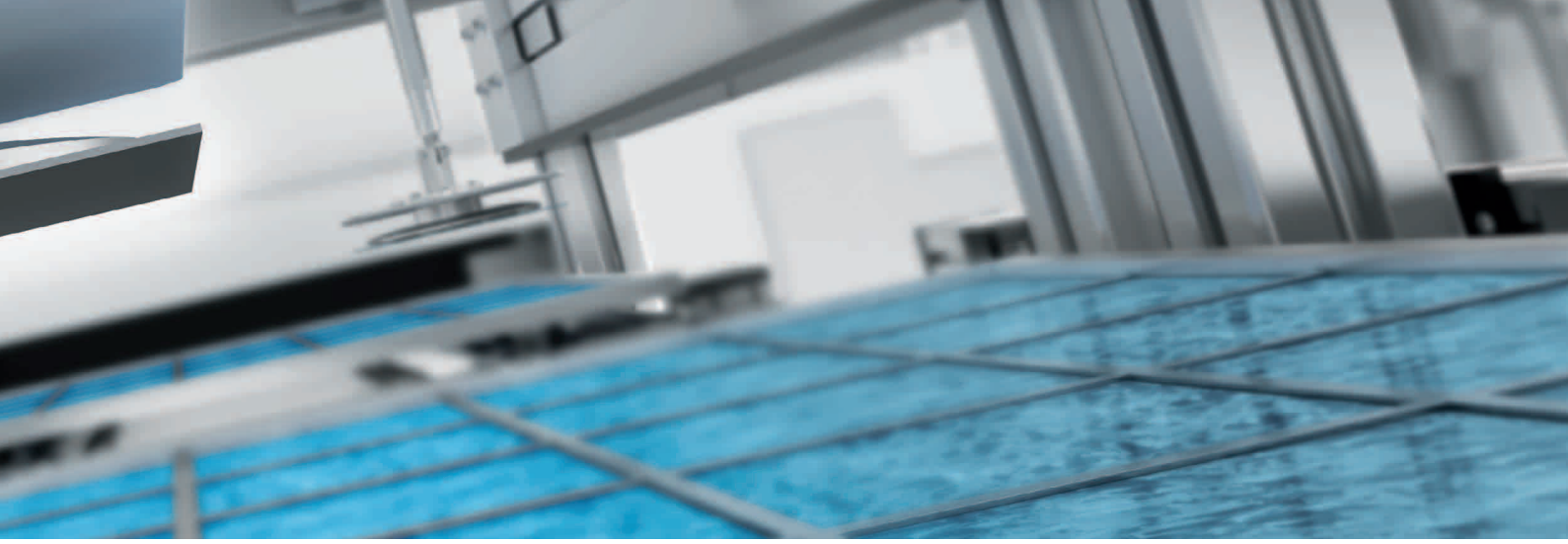
Advantages
- Solution available worldwide at any time
- Modular structure: usable in various types of systems
- Integrated in the system: potential for cost reductions in the clean room
- Complete solution from Festo – tested for functionality and thoroughly documented
- Global after sales service in 176 countries



Example of a customised solution with standardised functions for cooling water distribution



The individual cooling water circuits are of customised design



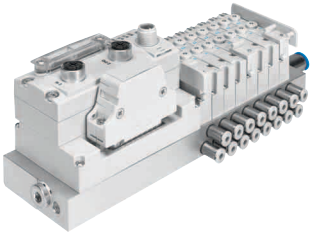
Gas box applications: reliable pilot valve applications with VTOC

Application
A number of front-end applications require totally reliable pilot control of the process valves.

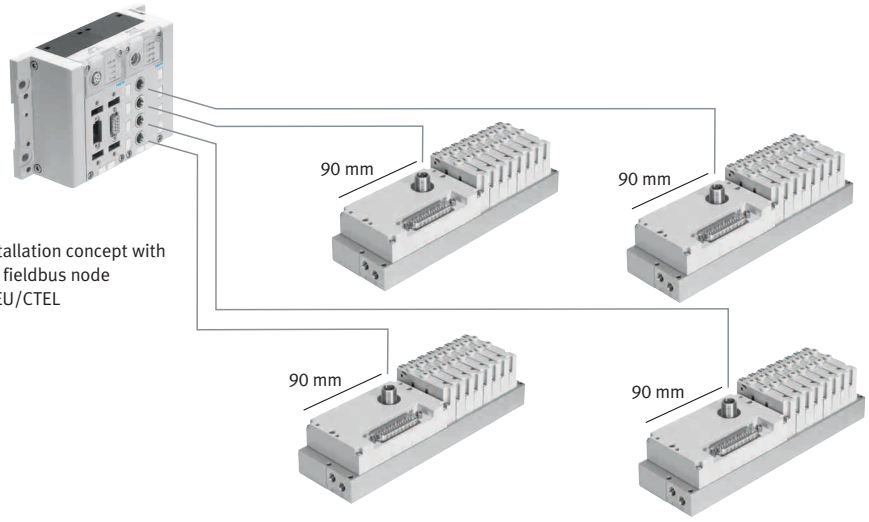
Challenge
The pilot valve terminal VTOC is ideal in gas boxes in which gas is prepared for the coating processes in the flat panel and solar industry. In this application the different gases are mixed. The VTOC actuates the process valves and ensures an optimum gas supply.

Solution
The pilot valve terminal VTOC is actuated, on the one hand, via conventional fieldbuses, e.g. EtherCAT®. On the other hand, an optional hardware interlock can be used to prevent unintentional switching of the valves. The gas supply is only released via the gas valves when there is a release signal at both channels. A connection concept based on CTEU/CTEL is available for price-sensitive applications. This concept enables up to four valve terminals to be actuated via a fieldbus node by means of a cost-optimised connection.

Advantages
- Modular design
- Modular system for the mechanics of the valves
- Highly flexible due to Optima interface for fieldbus and EtherCAT® connection
- Unipolar and bipolar interlocks possible
- Flexible printed circuit board open for all conventional fieldbuses



Valve terminal VTOC with fieldbus and interlock function



Installation concept with the fieldbus node CTEU/CTEL

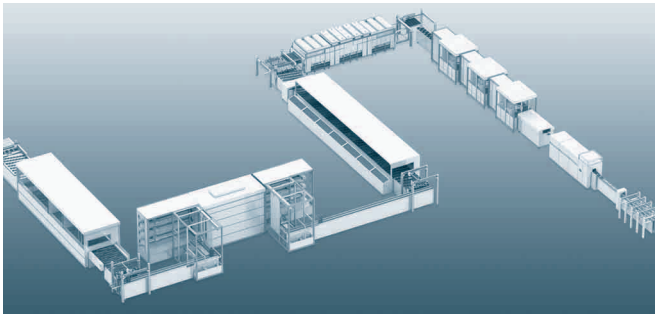
Your industry team supports you – worldwide

Short distances, quick and expert information, in-depth project understanding: this can only succeed if you have a contact who is very familiar with your project. That is why you always have the same contact from our industry team at Festo, who supports you worldwide. Regardless of where you are, whether your branch is in Europe, Australia, Asia or America. The industry experts from Festo are happy to provide you with advice and support at any time anywhere.

Please address your request simply to **solar@de.festo.com**

Ideas, suggestions and information can be found on the Internet at www.festo.com/solar

We have collected a great deal of suggestions and information for you at this link. Numerous animations and examples show you how innovative and process-reliable solutions can be created with Festo as a partner and what we can do. Click here to see our product and solution highlights. We promise your virtual visit will be worthwhile.



Provided consistently: comprehensive support

Festo's service and support philosophy is based on the continuous analysis of the value added chains of very different customers from the flat panel and solar industry, and from other sectors as well. Festo has utilised this knowledge to develop a sophisticated portfolio that supports you along your entire value added chain.

Engineering: clever concepts, innovative systems
- Consultation
- Research and engineering tools
- Sizing tools
- Electronic catalogue
- 3D data

Operation and maintenance: high system availability, money saved!
- Energy saving service
- Modular service contracts
- Spare parts catalogue/ repair service
- Support portal for documentation

Installation and commissioning: simple, flexible and fast!
- Ready-to-install solutions
- Commissioning of axis systems
- Free ePlan and CoDeSys macros

Procurement and logistics: everything from a single source!
- Festo online shop
- 24-hour delivery service
- Logistics optimisation service
- PrePack

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