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1. What information will you find in this manual?

What is CIROS® Production?

CIROS® Production is an application from the CIROS® Automation Suite. CIROS® Production is a PC-based graphical 3D simulation system which offers an introduction to computer-integrated manufacturing. You can use CIROS® Production to

- model production lines of differing degrees of complexity,
- automatically generate a production control system for a production line or program parts of the production control system yourself
- simulate the operation of the production line and
- plan production on the basis of a production database.

The fact that you are working with a complete production process means that you have a global perspective and can obtain a good overview of computer-integrated manufacturing and a clear understanding of the reciprocal effects and dependencies between the individual elements of a production process.

It is equally possible to concentrate on individual aspects of CIM plants and increase your depth of knowledge of these. Examples include robot and CNC programming.

In this way, you can by using the CIROS® Production simulation system acquire comprehensive knowledge and experience of CIM plants.

The simulated production lines are also available as real iCIM installations. These allow you to apply the knowledge you have acquired with virtual production lines to real installations and increase the depth of this knowledge.

This procedure is supported by a CIROS® Production expansion module. The expansion module makes it possible to control corresponding real production lines directly from CIROS® Production.
1. What information will you find in this manual?

Target group

This manual is aimed at
- trainers
  The manual offers trainers ideas and suggestions for ways to use CIROS® Production for training purposes at various levels.
- trainees
  For this group, the most interesting part of the manual will be the information and instructions on the operation of CIROS® Production.

Structure of manual

The manual is structured on the basis of the following thematic areas:
- Chapter 2 contains information and tips on the installation and licencing of CIROS® Production.
- Chapters 3 and 4 describe the system and the main operator functions of CIROS® Production.
- Chapter 5 deals with didactic matters. It lists the material taught by CIROS® Production and describes its learning concept and its possible uses in teaching.
- Chapter 6 describes concrete exercises using the taught materials, methodology for finding solutions and ways to implement these in CIROS® Production.

Conventions

In order to allow you to find information more easily, certain notation is used for text and for key combinations and sequences.

<table>
<thead>
<tr>
<th>Notation</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bold</td>
<td>Bold type is used for command names, menu name, dialogue field names, folder names and command options</td>
</tr>
<tr>
<td>Key 1 + key 2</td>
<td>A plus sign (+) between the key names means that you must press the named keys at the same time</td>
</tr>
<tr>
<td>Key 1 – key 2</td>
<td>A minus sign (-) between the key names means that you must press the named keys one after the other</td>
</tr>
</tbody>
</table>
1. What information will you find in this manual?

<table>
<thead>
<tr>
<th>Additional support</th>
<th>Further information and support is available as on-line help. On-line help consists of the following:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• CIROS® help for system operation of CIROS® Studio</td>
</tr>
<tr>
<td></td>
<td>• CIROS® Production Assistant</td>
</tr>
<tr>
<td></td>
<td>• CIROS® Supervision help</td>
</tr>
</tbody>
</table>

| CIROS® help | CIROS® help provides detailed information on the functions and operation of CIROS® Studio. The on-line help menu bar offers functions which will be familiar to you from standard Internet browsers. These include forward and back keys, a start-page button, the ability to print out selected subjects, the option to view or hide the navigation bar, and the ability to define Internet connection options. You also have a facility via additional tabs such as Contents, Index, Search and Favourites to navigate through the help information on CIROS® Studio in a convenient way. |

| CIROS® Production Assistant | Detailed information and instruction on the system operation of CIROS® Production can be found in CIROS® Production Assistant. CIROS® Production Assistant also provides detailed functional descriptions and technical documentation on the individual automation stations. Each functional description includes a list of the macro process tasks which each station can execute. The macro process tasks are a central part of the control system for a production line. CIROS® Production Assistant also includes the electronic version of the CIROS® Production manual. |
1. What information will you find in this manual?

**CIROS® Supervision help**

Supplementary information on programming production control systems in CIROS® Production can be found in the CIROS® Supervision manual. CIROS® Supervision help includes the electronic version of this manual.

You need to have Adobe Acrobat Reader installed on your PC in order to read PDF documents. The Adobe Acrobat Reader is available free of charge and can be downloaded from the website www.adobe.de. If you have any questions on the installation or operation of CIROS® Production, our telephone hot line is open to you at all times.
2. How to install CIROS® Production

To install CIROS® Production you will need the CIROS® Automation Suite DVD-ROM, where all the software packages of the CIROS® Automation Suite are ready for installation. It also includes the manuals in the form of PDF documents for the individual software packages. On completion of the installation, you will need to execute the licencing. As soon as this is successfully completed you can start CIROS® Production.

For further information regarding system requirements, installation and licencing, please refer to the enclosed instructions.
3. The CIROS® Production system

The CIROS® Production system includes:
- CIROS® Production simulation software
- A production database as a Microsoft Access application
- A runtime version of Microsoft Access
- An on-line CIROS® Studio help system
- An on-line CIROS® Production Assistant
- An on-line CIROS® Supervision help system
- A dongle for a USB interface
- A manual in the form of a PDF document for the operation of CIROS® Production.

3.1 Overview of CIROS® Production

CIROS® Production is a PC-based graphical 3D simulation system which offers an introduction to computer-integrated manufacturing. You can use CIROS® Production to plan, program and simulate production lines.

Example of a production line
3. The CIROS© Production system

Production lines consist of one or more production cells. Within CIROS© Production, production cells are also referred to as automation stations. Production cells are made up of several automation devices. Typical automation devices are processing stations such as industrial robots or CNC machines. Additional devices such as peripheral devices and conveyor systems are also used. The most important feature of production cells is that they work together to process various products within the production process. The processing sequence is programmed in the production control system.

Production lines are also called production cells in CIROS© Production software, and are administrated as such.

When you carry out production planning for production cells or production lines, you are working on the Enterprise Resource Planning (ERP) level within a factory automation hierarchy.

The actual control process for production lines runs on the Manufacturing Execution System (MES) level.

The Controls (or “Shopfloor”) level is the lowest level within the factory hierarchy. On this level you will find real or virtual production lines and automation components.
3. The CIROS® Production system

CIROS® Production offers an introduction to computer-integrated manufacturing. It covers the CONTROLS and MES levels completely and also parts of the ERP level.

For the CONTROLS level, CIROS® Production offers the function:
- Creation of a production line.

For the MES level, CIROS® Production offers the following functions:
- Creation of relevant project for production control system
- Automatic creation of production control system for production line
- Optional: Programming of production control system using process plan
- Simulation of production line operation
3. The CIROS® Production system

For the ERP level, CIROS® Production offers the function;
- Planning of production on the basis of a production database

The functions of CIROS® Production are implemented in three program sections:
- iCIM Production Manager
- Production Simulation
- Production Supervision
3. The CIROS® Production system

Production Simulation

The plant editor within the Production Simulation program section allows modelling of production lines on the basis of ready-made automation stations. The automation-station data is stored in a library. As soon as you begin to simulate a production line, working from Production Supervision, you can use Production Simulation to follow events on the production line in a highly realistic way.

Production Simulation program section

The library offers a variety of automation stations and devices. These include:
- Various robots
- Various CNC machine tools
- Equipment for quality testing and inspection
- Automated warehouse with automatic infeed and outfeed of workpieces

Production Supervision

The Production Supervision program section allows you to create a project for a production control system for a production line. Data on the type and composition of the production plant is automatically exchanged between the Production Simulation and Production Supervision program sections. A production control program can be created automatically. Alternatively, it is possible to expand this program, optimise it or program parts of the production control system using process plan.
3. The CIROS® Production system

The following central tasks are carried out on production lines or in production cells:

- Workpieces are taken from the stores and transported to the machine tools.
- Robots pick workpieces from a conveyor belt and set these down at defined positions within a station.
- CNC machines process workpieces.
- Assembly machines fit two or more workpieces together to form an end product.
- Special stations check the quality of the workpieces produced.

When the operation of a production line is simulated, a visualisation with simple operator functions is automatically created at the same time. Data on stock levels and facilities for operator intervention are also available in the Production mode.
3. The CIROS® Production system

ProductionManager allows you to carry out simple functions of a production planning system. These include:

- Creation of new workpieces by entering an order number and an assembly instructions number on the production database.
- Setting up a production process for new workpieces on the production database and describe this.
- Compilation and execution of a task table on the basis of a pre-defined production database.
- Display of the latest data on the stage reached in the processing of the task table.
- Management of an automated warehouse.

ProductionManager program section
3. The CIROS® Production system

3.2 A production line in CIROS® Production

A production line in CIROS® Production consists of the following elements:
- Conveyor belt
- Automated warehouse
- Processing and assembly stations
- Optional: Quality station
- Production control with visualisation
- Production database

![Schematic representation of a production line]

The tasks of a materials flow system are:
- Transport of workpieces between automation stations
- Transport of workpieces within an automation station

**Example:**
Laying a workpiece on a conveyor belt, taking a workpiece from a station magazine.

Workpieces are generally transported between the various automation stations by means of a conveyor belt. Conveyor-belt pallet carriers are used to bring pallets of workpieces to the desired automation station. A robot is responsible for the transport of workpieces within the station.
When a robot accepts a pallet with a workpiece from a conveyor belt, it will typically set this down at a buffer station. From this point, the robot will feed the workpiece to a processing or assembly process. After the desired process has been carried out, the robot will replace the workpiece on the pallet and then feed the pallet with the processed workpiece onto a pallet carrier on the conveyor belt.

An automated warehouse is used as the main storage point for a production line. Each warehouse compartment accepts one workpiece on a pallet. The workpieces are fed from this point to the individual stations.

In addition to this main storage point, there are also local storage points for the stations. These storage points are allocated to individual stations and managed by these. This allows stations to operate independently of the main storage point. Typical storage points within stations take the form of magazines and belt systems.

Each automation station carries out certain tasks. The execution of these tasks is defined in programs. These programs – which include PLC, CNC and robot programs – are an integral part of the automation station in question.
3. The CIROS® Production system

3.3 Production control in CIROS® Production

The production control system used in CIROS® Production has a hierarchical and easily adaptable structure.

Example

Here is an example to explain the mode of operation of the production control system:

The task for the production line is as follows:

- **The product**: aluminium desk set with aluminium pen holder and thermometer is to be produced.

Ask yourself: What tasks does the production control system need to carry out? What data does this system need? What conditions must be fulfilled?

The table below summarises the most important steps in the production of the desk set.

<table>
<thead>
<tr>
<th>No.</th>
<th>Process steps</th>
<th>Execution of steps</th>
</tr>
</thead>
</table>
| 1   | What is the part number of the desired product? | All the workpieces required for production have their own part number and are described on the production database by a number of features.  
⇒ By accessing the production database, we find:  
The desired product has the part number 52368. |
| 2   | Issue of order to production line. | ➔ Order is added to production table:  
Produce part no. 52368.  
START. |
| 3   | What workpieces are required for the product? | Data on the workpieces which make up a particular product is stored on the production database.  
⇒ By accessing the production database, we find:  
The desk set consists of a baseplate (part number 42140) and a pen holder (part number 42102). These workpieces are supplied from the warehouse.  
Also present in the assembly station are stocks of the thermometer (part number 30000) and the pen (part number 30100). |
3. The CIROS® Production system

<table>
<thead>
<tr>
<th>No.</th>
<th>Process steps</th>
<th>Execution of steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>What resources (in this case machines) are required for the production process?</td>
<td>Data on the required resources is also stored on the production database.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>➔ By accessing the production database, we find:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>We required an automated warehouse, a circulating belt system, a lathe and a milling machine.</td>
</tr>
<tr>
<td>5</td>
<td>Does the production line contain the required machines?</td>
<td>A check as to whether the required resources are available is made by evaluating the project. This contains a list of all production line devices.</td>
</tr>
<tr>
<td></td>
<td>In CIROS® Production, machines are also referred to as automation stations.</td>
<td>➔ By evaluating the project, we find:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The required resources are available.</td>
</tr>
<tr>
<td>6</td>
<td>What steps need to be executed during the production of the products?</td>
<td>The actual production sequence is formulated in a special programming language:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>➔ Command to belt: Position pallet carrier in front of stores.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Command to stores: Set down workpiece on pallet carrier.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Command to belt: Transport pallet carrier to NC machine.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.....</td>
</tr>
<tr>
<td>7</td>
<td>What is the criterion for the end of the production process?</td>
<td>The production control system supplies status and error messages to the production process.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>➔ The production order is complete: END</td>
</tr>
</tbody>
</table>
If we evaluate the production process, we come to the following conclusions:

- The production line and production control system has a hierarchical structure.
- In order to be able to address the individual devices, the production control system must possess data on the structure and devices of the production line.
- The sequence for the production control system is written in a special programming language. In CIROS® Production, the programming language “process plan” is used.
- In order to allow automatic production, all data on the workpieces and production process must be stored on a database. The production control system then accesses this database.
3. The CIROS® Production system

The production control system for production lines has a hierarchical structure. Each hierarchical level has defined tasks and defined interfaces to the adjacent levels.
3. The CIROS® Production system

The production line control system includes:

- **Executable device programs:**
  Production lines consist of automation stations. Automation stations in turn consist of various devices such as robots, a PLC or a CNC machine. Devices, including automation stations, carry out certain tasks. The individual tasks are stored as programs. These programs are called up selectively by the production control system.
  
  **Example:**
  Robot programs for the Festo Assembly Station or PLC programs for the Festo Stock Station.

- **Process tasks of devices:**
  The individual tasks of a device are referred to as process tasks. Each device has certain process tasks. In the interests of simplicity and user-friendliness, automation stations operate with so-called macro process tasks. Macro process tasks describe the major tasks of a station. Macro process tasks are made up of the process tasks for the individual devices.
  
  **Example:**
  The Festo Assembly Station has macro process tasks such as AsmDeskSet (Assembly Desk Set), MovFromTrans (Move From Transport) and MovToTrans (Move To Transport).

- **PC-based production control system:**
  The process tasks are called up by the master production control system. In certain cases, further data will also need to be transferred to the process task in the form of parameters. After a device has completed a process task, it sends a feedback signal confirming this to the calling production control system.
  
  **Example:**
  Macro process task DeskSet (TargetPartNumber, OrderNumber).
  The macro process task AsmDeskSet includes the parameters TargetPartNumber and OrderNumber. TargetPartNumber indicates the part number of the product which is to be assembled, while OrderNumber is the number of the production order.
3. The CIROS<sup>®</sup> Production system

- Networking
  
  The production control system and the devices must be networked to allow them to exchange data.

  **Example:**
  
  Networking via Ethernet using the TCP/IP protocol or an RS 232 serial interface in the case of a real production line, networking via PARSIFAL in the case of a simulated production line.

- Drivers:
  
  The process tasks or macro process tasks of a device are contained in a driver and its associated handshake process plan. The driver is a program which addresses a device directly. The driver communicates on one side with the production control system via the appropriate network and on the other side with the device. The communication with the device also follows certain rules. The driver thus links the production control system and the device. The driver and the associated handshake process plan convert the process tasks into a form in which it can be executed by the device.

  **Example:**
  
  The driver $PARSIFAL$ communicates with all the devices on the simulated production line, including the Robot Assembly1Robot1 devices of the Festo Assembly Station. For example, the driver converts the process tasks ExecProg ("MP", 15, 3, 0) in such a way that the robot program with the specified name MP is executed. In this robot program, the robot picks a pallet from the circulating conveyor belt and sets this down at buffer station 3 of the Festo Assembly Station.
3. The CIROS® Production system

The production control system is programmed using a special high-level language, process plan. This language provides many system functions such as arithmetic or character string functions. Character string functions, for example, can be used to create messages for machine operators. System functions are required for, among other things, the initialisation and de-initialisation of drivers and devices. In addition to basic functions, there are also commands for process tasks and macro process tasks.

The hierarchical structure ensures that the production control system is highly flexible. This flexibility is achieved through the use of device-specific drivers and their associated handshake process plan.

- The device drivers are programmable. They can thus be modified at any time for new tasks.
- If a different or new automation device is installed, it is only necessary to create a new driver and a new handshake process plan for this device and load it into the system. The existing parts of the production control system will not be affected by this change. Drivers and handshake process plans can be programmed by skilled users or by the system manufacturer.
- Any changes to the robot or PLC programs will not affect the production control system.
- Changes to the production process can be made easily by the user. It is only necessary for the user to modify the process plan appropriately.
- The use of device-specific drivers makes it possible to use the production control system with heterogeneous cell structures.
3. The CIROS® Production system

Example of production lines

Process plans for production control system

The product-specific production process in the production cell is defined for each product by a separate process plan.

The following applies to process plans:

- A process plan is executed by the production control system as an applications program.
- A process plan contains all the process steps for an individual product.
- A process plan can be programmed freely by users. The CIROS® Production system provides support for the programming of process plans.
3. The CIROS® Production system

Modes of operation of production control system

A production control system offers various modes of operation:
- In the set-up mode, you can create a program for the production control system. During this time, the production line is at a standstill.
- In the Production mode, the production control system program will be executed and the production line will operate.

3.4 The structure of a project in CIROS® Production

CIROS® Production allows the user to create production lines with their associated production control systems. The production lines are managed as a project.

A CIROS® Production project thus contains data on:
- The configuration – in other words, the structure and composition – of the production line and
- The production line control system.

Data on the project is supplied by various project elements.

<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Devices</td>
<td>A production line is made up of various automation stations. The automation stations in turn consist of devices.</td>
</tr>
<tr>
<td>Process plans</td>
<td>Process plans describe the sequence of the production process on the production line. They form part of the production control system.</td>
</tr>
<tr>
<td>Drivers</td>
<td>Drivers are assigned to individual devices. The drivers, together with the handshake process plans, cover the possible process tasks of an individual device. They convert the process tasks in such a way that they can be executed by the devices. Drivers also form part of the production control system.</td>
</tr>
<tr>
<td>Libraries</td>
<td>Individual project elements to control the production line can be linked in from libraries. Libraries thus also form part of the production control system.</td>
</tr>
</tbody>
</table>
3. The CIROS® Production system

<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processes</td>
<td>Processes are not static project elements. They are created during the operation of the production control system (Production mode) as manifestations of the execution of process plans.</td>
</tr>
<tr>
<td>Process tasks</td>
<td>Processes are not static project elements. They are created during the operation of the production control system (Production mode) when individual process tasks are started in devices.</td>
</tr>
</tbody>
</table>
3. The CIROS® Production system

**Devices**

A production line is made up of various automation stations. The automation stations in turn consist of devices. The project element Devices shows both the stations and the subordinate devices.

You can model the production line in Production Simulation. In order to ensure that the production line control system can be created automatically in Production Supervision, Production Supervision must have data on the production plant structure. The necessary data is available in an XML file.

The production control system transmits process tasks to the production line devices. This is carried out using a driver. All the process tasks of a device are grouped together in the driver and associated handshake process plan. Drivers are therefore always allocated to precisely one device.
3. The CIROS® Production system

In the Project window the following additional data is shown for each device:

- The allocated drivers with the name prefix $ and
- The process tasks.
3. The CIROS® Production system

Process plans are an important element of a production control system. Process plans are used to program the process sequences for a production line. They define the sequence in which the individual process steps are to be executed and also permit the creation of parallel branches.

Process plans have a line-oriented structure. Each line is made up of these fields:
- Line number
- Condition
- Device
- Process task
- Next line
- Comment (optional)

<table>
<thead>
<tr>
<th>Line</th>
<th>Condition</th>
<th>Device</th>
<th>Task</th>
<th>Next line</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
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<tr>
<td>3</td>
<td></td>
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<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Process plan automatically generated from Default template

Date: 11.05.05
Time: 14:15

END of automatically generated process plan

END of automatically generated process plan
3. The CIROS® Production system

In the **Project** window, the following process plans are displayed:

- The automatically generated process plans and
- The process plans generated by the user and stored in the **User** folder.
Drivers

Drivers are programs which, together with the handshake process plans, contain the process tasks of a device. Drivers thus form the interface between the production control system and a device. In behalf of the production control system, a driver start the process task of a device. Once this process task has been completed, the driver is supplied with the process result and relays this to the production control system.

A driver is allocated to each device. Drivers are suppliers by the device manufacturers.
A list of connected devices is also displayed as additional information in the Project window.
3. The CIROS® Production system

Libraries

Libraries are projects from which project elements can be copied or linked into the current project.

The following elements are displayed for each library in the Project window:

- Process plans
- Devices
- Drivers
Processes

Processes are not static project elements. They are created in the Production mode as manifestations of the execution of process plans. The associated variables are displayed for each process in the **Project** window.
3. The CIROS® Production system

Process tasks are also not static project elements. They are created during the operation of the production control system (Production mode) when individual process tasks are started in devices.

The associated process is displayed for process tasks in the Project window.
3. The CIROS® Production system

3.5 The pre-assembled automation stations

The models of pre-assembled automation stations are authentic representations of real existing CIM stations.

Each station model includes
- a graphical representation of the station and
- the robot and PLC programs for the associated devices.

The robot and PLC programs are called up by the production control system. The programs cannot be modified.

You can use these automation stations to model production lines with different functionality.

<table>
<thead>
<tr>
<th>Automation stations</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Festo 3x1 4P</td>
<td>Festo Transport System 4</td>
</tr>
<tr>
<td>Transport system as circulating belt system with 4 stopper positions and 6 pallet carriers. The stopper positions are located both on the long sides and ends of the transport system.</td>
<td></td>
</tr>
<tr>
<td>Festo 3x1 4PV1</td>
<td>Festo Transport System 4V1</td>
</tr>
<tr>
<td>Transport system as circulating belt system with 4 stopper positions and 6 pallet carriers. Three stopper positions are located on the long sides, one stopper position is located on the end of the transport system.</td>
<td></td>
</tr>
</tbody>
</table>
### 3. The CIROS<sup>®</sup> Production system

<table>
<thead>
<tr>
<th>Automation stations</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Festo 4x1 6P&lt;br&gt;Transport System 6</td>
<td>Transport system as circulating belt system with 6 stopper positions and 6 pallet carriers. The stopper positions are located both on the long sides and ends of the transport system.</td>
</tr>
<tr>
<td>FMF-G 3x1 4P&lt;br&gt;Transport System 4</td>
<td>Transport system as circulating belt system with 4 stopper positions and 6 pallet carriers. The stopper positions are located both on the long sides and ends of the transport system.</td>
</tr>
<tr>
<td>FMF-G 3x1 4PV1&lt;br&gt;Transport System 4V1</td>
<td>Transport system as circulating belt system with 4 stopper positions and 6 pallet carriers. Three stopper positions are located on the long sides, one stopper position is located on the end of the transport system.</td>
</tr>
<tr>
<td>FMF-G 4x1 6P&lt;br&gt;Transport System 6</td>
<td>Transport system as circulating belt system with 6 stopper positions and 6 pallet carriers. The stopper positions are located both on the long sides and ends of the transport system.</td>
</tr>
</tbody>
</table>
### Automation stations

<table>
<thead>
<tr>
<th>Description</th>
<th>Automation stations</th>
</tr>
</thead>
<tbody>
<tr>
<td>FMF-G 6x1 6PV1 Transport System 6V1</td>
<td><img src="image1.png" alt="Image" /> Transport system as circulating belt system with 6 stopper positions and 10 pallet carriers. The stopper positions are located on the ends of the transport system only.</td>
</tr>
<tr>
<td>FMF-G 6x1 6PV2 Transport System 6V2</td>
<td><img src="image2.png" alt="Image" /> Transport system as circulating belt system with 6 stopper positions and 10 pallet carriers. The stopper positions are located both on the long sides and ends of the transport system.</td>
</tr>
<tr>
<td>FMF-G 6x1 8P Transport System 8</td>
<td><img src="image3.png" alt="Image" /> Transport system as circulating belt system with 8 stopper positions and 10 pallet carriers. The stopper positions are located both on the long sides and ends of the transport system.</td>
</tr>
<tr>
<td>Single Stock Station</td>
<td><img src="image4.png" alt="Image" /> Single automated warehouse with 5 x 8 storage locations.</td>
</tr>
</tbody>
</table>
### Automation stations

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Double Stock Station</strong>&lt;br&gt;Double automated warehouse with 11 x 8 storage locations. There are 40 storage bins in the front row of the automated warehouse, and 48 in the back row.</td>
</tr>
<tr>
<td><strong>Stock Station ASR 16</strong>&lt;br&gt;Single automated warehouse with 4 x 4 storage locations.</td>
</tr>
</tbody>
</table>
### Automation stations

<table>
<thead>
<tr>
<th>Stock Station ASR 50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single automated warehouse with 5 x 10 storage locations.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>QH 200 Handling &amp; Quality Station</th>
</tr>
</thead>
<tbody>
<tr>
<td>Handling &amp; quality station for checking of milled workpieces.</td>
</tr>
</tbody>
</table>
### 3. The CIROS® Production system

<table>
<thead>
<tr>
<th>Automation stations</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAC-405 Assembly Station RH-SA55</td>
<td></td>
</tr>
<tr>
<td>Robot assembly station with SCARA robot, vision system and magazines as local storage locations.</td>
<td></td>
</tr>
<tr>
<td>FAC-601 Assembly Station RV-1A</td>
<td></td>
</tr>
<tr>
<td>Robot assembly station with RV-1A robot, vision system and chutes.</td>
<td></td>
</tr>
</tbody>
</table>
### Automation stations

<table>
<thead>
<tr>
<th>Automation stations</th>
<th>Description</th>
</tr>
</thead>
</table>
| FAC-602             | Assembly Station RV-2A  
Robot assembly station with RV-2A robot, vision system and chutes. |
| FAC-502             | Assembly Station RV-2AJ  
Robot assembly station with RV-2AJ robot, vision system and chutes. |
3. The CIROS® Production system

<table>
<thead>
<tr>
<th>Automation stations</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAC-603</td>
<td>Assembly Station RV-3SB</td>
</tr>
<tr>
<td></td>
<td>Robot assembly station with RV-3SB robot, vision system and magazines which serve as local storage locations.</td>
</tr>
<tr>
<td>FCT 56</td>
<td>Turn Station 55</td>
</tr>
<tr>
<td></td>
<td>Robot station RV-1A with EMCO Turn 55 CNC lathe.</td>
</tr>
</tbody>
</table>
### Automation stations

<table>
<thead>
<tr>
<th>Automation stations</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FCT 105 Turn Station 105 RV-2AJ</td>
<td>Robot station RV-1AJ with EMCO Turn 105 CNC lathe.</td>
</tr>
<tr>
<td>FCT 126 Turn Station 105 RV-3SB</td>
<td>Robot station RV-3SB with EMCO Turn 105 CNC lathe.</td>
</tr>
</tbody>
</table>
3. The CIROS® Production system

<table>
<thead>
<tr>
<th>Automation stations</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FCT 166 Turn Station 155</td>
<td>Robot station RV-2A with EMCO Turn 155 CNC lathe.</td>
</tr>
<tr>
<td>FCM 56 Mill Station 55</td>
<td>Robot station RV-1A with EMCO Mill 55 CNC milling machine.</td>
</tr>
</tbody>
</table>
3. The CIROS® Production system

<table>
<thead>
<tr>
<th>Automation stations</th>
<th>Description</th>
</tr>
</thead>
</table>
| FCM 105             | Mill Station 105 RV-2AJ  
Robot station RV-2AJ with EMCO Mill 105 CNC milling machine. |
| FCM 126             | Mill Station 105 RV-3SB  
Robot station RV-3SB with EMCO Mill 105 CNC milling machine. |
3. The CIROS® Production system

<table>
<thead>
<tr>
<th>Automation stations</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FCM 166 Mill Station 155 Robot station RV-2A with EMCO Mill 155 CNC milling machine.</td>
<td></td>
</tr>
<tr>
<td>FCMT 105 Mill &amp; Turn Station 105 RV-2A</td>
<td>Robot RV-2A station on linear axis with EMCO Mill 105 CNC milling machine and EMCO Turn 105 CNC lathe.</td>
</tr>
</tbody>
</table>
3. The CIROS® Production system

<table>
<thead>
<tr>
<th>Automation stations</th>
<th>Description</th>
</tr>
</thead>
</table>
| FCMT 126            | Mill & Turn Station 105 RV-3SB  
Robot RV-3SB station on linear axis with EMCO  
Mill 105 CNC milling machine and EMCO Turn 105 CNC lathe. |
| FCMT 56             | Mill & Turn Station RV-1A  
Robot RV-1A station on linear axis with EMCO Mill  
155 CNC milling machine and EMCO Turn 155 CNC lathe. |
| FCMT 166            | Mill & Turn Station RV-2A  
Robot RV-2A station on linear axis with EMCO Mill  
155 CNC milling machine and EMCO Turn 155 CNC lathe. |
3. The CIROS® Production system

<table>
<thead>
<tr>
<th>Automation stations</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FCMT 176</td>
<td>Mill &amp; Turn Station RV-3SB</td>
</tr>
<tr>
<td>RV-3SB</td>
<td>Robot station RV-3SB on linear axis with CNC milling machine EMCO Mill 155 and CNC lathe EMCO Turn 155.</td>
</tr>
</tbody>
</table>
3. The CIROS® Production system

3.6 The products

With CIROS® Production, you can produce:
- Desk sets in a number of variants
- Intermediate products for desk sets

Example of product

The desk set has three drilled holes:
- One hole is intended for a pen holder
- Two are intended as instrument holders
3. The CIROS® Production system

You can produce the desk set in numerous variants. The variants are created by selecting different component variants. The details are as follows:

- The aluminium base plate can be produced in 5 variants. These are of different designs.
- There is a choice of aluminium or brass as the material for the pen holder.
- 5 variants are possible for the aluminium or brass pen holder. These are of different design.
- The pen holder can be equipped with a ballpoint pen or left empty.
- Each instrument holder position can be equipped with a thermometer or hygrometer or left empty.
3. The CIROS® Production system

<table>
<thead>
<tr>
<th>Base plate variants, untested</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base plate type 1, untested</td>
<td>Base plate for desk set, aluminium type 1: Basic version</td>
</tr>
<tr>
<td></td>
<td>The base plate is untested</td>
</tr>
<tr>
<td></td>
<td>Part no.: 42 140</td>
</tr>
<tr>
<td>Base plate type 2, untested</td>
<td>Base plate for desk set, aluminium type 2: with small chamfer</td>
</tr>
<tr>
<td></td>
<td>The base plate is untested</td>
</tr>
<tr>
<td></td>
<td>Part no.: 42 141</td>
</tr>
<tr>
<td>Base plate type 3, untested</td>
<td>Base plate for desk set, aluminium type 3: with large chamfer</td>
</tr>
<tr>
<td></td>
<td>The base plate is untested</td>
</tr>
<tr>
<td></td>
<td>Part no.: 42 142</td>
</tr>
<tr>
<td>Base plate type 4, untested</td>
<td>Base plate for desk set, aluminium type 4: with small rounding</td>
</tr>
<tr>
<td></td>
<td>The base plate is untested</td>
</tr>
<tr>
<td></td>
<td>Part no.: 42 143</td>
</tr>
<tr>
<td>Base plate type 5, untested</td>
<td>Base plate for desk set, aluminium type 5: with large rounding</td>
</tr>
<tr>
<td></td>
<td>The base plate is untested</td>
</tr>
<tr>
<td></td>
<td>Part no.: 42 144</td>
</tr>
<tr>
<td>Base plate variants, tested</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------</td>
<td>-------------</td>
</tr>
</tbody>
</table>
| ![Base plate type 1](image1.png) | Base plate type 1  
Base plate for desk set, aluminium type 1: Basic version  
The base plate is tested  
Part no.: 46 140 |
| ![Base plate type 2](image2.png) | Base plate type 2  
Base plate for desk set, aluminium type 2: with small chamfer  
The base plate is tested  
Part no.: 46 141 |
| ![Base plate type 3](image3.png) | Base plate type 3  
Base plate for desk set, aluminium type 3: with large chamfer  
The base plate is tested  
Part no.: 46 142 |
| ![Base plate type 4](image4.png) | Base plate type 4  
Base plate for desk set, aluminium type 4: with small rounding  
The base plate is tested  
Part no.: 46 143 |
| ![Base plate type 5](image5.png) | Base plate type 5  
Base plate for desk set, aluminium type 5: with large rounding  
The base plate is tested  
Part no.: 46 144 |
3. The CIROS® Production system

<table>
<thead>
<tr>
<th>Variants of aluminium penholder</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penholder type 1</td>
<td>Penholder, aluminium Type 1, 1 slot Part no.: 42 100</td>
</tr>
<tr>
<td>Penholder type 2</td>
<td>Penholder, aluminium Type 2, 2 slots Part no.: 42 101</td>
</tr>
<tr>
<td>Penholder type 3</td>
<td>Penholder, aluminium Type 3, 3 slots Part no.: 42 102</td>
</tr>
<tr>
<td>Penholder type 4</td>
<td>Penholder, aluminium Type 4, 4 slots Part no.: 42 103</td>
</tr>
<tr>
<td>Penholder type 5</td>
<td>Penholder, aluminium Type 5, 5 slots Part no.: 42 104</td>
</tr>
</tbody>
</table>
### Variants of brass penholder

<table>
<thead>
<tr>
<th>Variants of brass penholder</th>
<th>Description</th>
</tr>
</thead>
</table>
| Penholder type 1            | Penholder, brass  
Type 1, 1 slot  
Part no.: 42 120 |
| Penholder type 2            | Penholder, brass  
Type 2, 2 slots  
Part no.: 42 121 |
| Penholder type 3            | Penholder, brass  
Type 3, 3 slots  
Part no.: 42 122 |
| Penholder type 4            | Penholder, brass  
Type 4, 4 slots  
Part no.: 42 123 |
| Penholder type 5            | Penholder, brass  
Type 5, 5 slots  
Part no.: 42 124 |
3. The CIROS® Production system

<table>
<thead>
<tr>
<th>Components for fitting</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Thermometer</td>
</tr>
<tr>
<td></td>
<td>Thermometer</td>
</tr>
<tr>
<td></td>
<td>Part no.: 30 000</td>
</tr>
<tr>
<td></td>
<td>Hygrometer</td>
</tr>
<tr>
<td></td>
<td>Hygrometer</td>
</tr>
<tr>
<td></td>
<td>Part no.: 30 001</td>
</tr>
<tr>
<td></td>
<td>Ballpoint pen</td>
</tr>
<tr>
<td></td>
<td>Ballpoint pen</td>
</tr>
<tr>
<td></td>
<td>Part no.: 30 100</td>
</tr>
</tbody>
</table>
3. The CIROS® Production system

<table>
<thead>
<tr>
<th>Blanks</th>
<th>Description</th>
</tr>
</thead>
</table>
| Aluminium blank | Blank for penholder, aluminium  
Diameter: 30 mm  
Length: 58 mm  
Part no.: 42 000                                                  |
| Blank Brass     | Blank for penholder, brass  
Diameter: 30 mm  
Length: 58 mm  
Part no.: 42 001                                                  |
| Baseplate blank | Blank for baseplate, aluminium  
Part no.: 42 010                                                  |
3. The CIROS® Production system

3.7 The production database

The production database manages all the data associated with a computer-integrated production process. During the production process, this data is available to all the machines and personnel involved in the process.

The data is structured and compiled into tables. The totality of all the tables form the production database.

<table>
<thead>
<tr>
<th>Workpieces table</th>
<th>Production process table</th>
<th>Customer table</th>
<th>... table</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part no.</td>
<td>Part no.</td>
<td>Customer no.</td>
<td>...</td>
</tr>
<tr>
<td>Designation</td>
<td>Machine</td>
<td>Address</td>
<td>...</td>
</tr>
<tr>
<td>Type</td>
<td>Machine program number</td>
<td>Order no.</td>
<td>...</td>
</tr>
<tr>
<td>Design</td>
<td>Type of production process</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

Production database

The production database contains data on:
- Stock management
- Products, intermediate products and blanks
- Production process resources, including, for example, transport devices and machine tools
- The quality of the produced workpieces
- Customers and their orders
3. The CIROS® Production system

As delivered, the CIROS® Production production database contains data on a number of workpieces. These are:
- Blanks
- Intermediate products
- End products

You can use these blanks and intermediate products to define new end products and store their data on the database. There are various database masks to allow you to input data.

A workpiece on the production database, for example, is characterised by the following data:
- Part no.
- Product designation
- Workpiece type: Produced in-house or outsourced
- Geometrical structure of workpiece
- Pallet
- Costs
- Sales price

A definition of the production process used for the workpiece needs the following data:
- The machine used to produce the workpiece
- The processing task which the machine needs to carry out
- The program used for this
- An indication as to whether the workpiece is processed or assembled from several parts
- An indication as to whether test data is to be generated for the produced workpiece
- The action to be taken with "bad" workpieces
3. The CIROS® Production system

Customer data such as the following:
- Address
- Customer number
- Order number
is also managed on the production database.

You need to define the stock level at the start of production. This level will then be automatically updated and adapted during the production process.
4. The most important operator functions of CIROS® Production

A full description of the most important operator functions and sample applications for CIROS® Production can be found in the CIROS® Production Assistant.
5. Material which you can teach using CIROS® Production

CIROS® Production is a PC-based graphical 3D simulation system which provides an introduction to computer-integrated manufacturing. The production lines created from pre-assembled automation components reflect practical applications. The exercises are based on authentic industrial handling operations and are designed to contribute to an holistic learning process. CIROS® Production allows you to provide training in methodological competence and competence of actions.

5.1 Learning contents and learning objectives

Learning objectives

CIROS® Production allows you to deal with and communicate learning contents from the following areas:
- Structure and mode of operation of production lines of different degrees of complexity
- Structure and mode of operation of flexible production control systems for production lines
- Programming of production control systems using process plans
- Production databases with data on products and blank workpieces as the basis for and an integral part of computer-aided automated production
- Basic functions of a production planning system.

Main learning objectives

The general learning objective which can be met with CIROS® Production is the development of skills in
- creating production lines using pre-assembled automation stations
- defining control sequences for production lines and
- simulating production line operation.

In accordance with this objective, CIROS® Production covers all the material which can be taught using virtual production lines or production cells.
5. Material which you can teach using CIROS® Production

Learning-objective areas

The following learning-objective areas are derived from the main learning objectives:

- Ability to generate production lines in graphical form using pre-assembled automation stations in CIROS® Production
- Ability to understand the basic structure of a production line consisting of various automation stations. Important automation stations include processing stations, test stations and transport systems.
- Ability to understand the communication and control principle of a production line in CIROS® Production.
- Ability to understand the structure of a project for a production line in CIROS® Production.
- Ability to generate and modify the production control system for a production line, for example programming an original production sequence for a production line.
- Ability to simulate the operation of a production line and create simple operator functions.
- Ability to control the operation of a production line using individual order tables.
- Familiarisation with production databases as an important element of computer-integrated manufacturing.
- Ability to modify the contents of a production database and, for example, create new workpieces.

5.2 Target group

The target group for CIROS® Production is everyone whose professional responsibilities include the planning and control of production lines or who wish to acquire basic knowledge of these.

The applications of CIROS® Production include:

- Technical training in computer-integrated manufacturing
- Training at technical colleges and universities in the discipline of industrial system planning
- Customers who have bought iCIM systems from the Festo Didactic Solution Centre.

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5. Material which you can teach using CIROS® Production

5.3 Previous knowledge required

The following previous knowledge is required in order to work and learn with CIROS® Production:

- Basic knowledge of control technology, the components of an automated system, material flow, information flow and energy flow in an automated system
- Basic knowledge of the information structure of automated systems, networking between subsystems, hierarchies in networked systems
- Basic knowledge of manufacturing and production processes
- Basic knowledge of PLC programming
- Basic knowledge of robot programming
- Basic knowledge of CNC programming
- Basic knowledge of high-level-language programming

5.4 The learning concept of CIROS® Production

CIROS® Production is a motivating multimedia learning package for the area of computer-integrated manufacturing.

CIROS® Production offers an easy introduction to the subject of computer-integrated manufacturing. In a first step, users select a product from a range of possible products. They then create a production line for this product from automation stations. As soon as a production control system has been automatically generated for the production line, users can simulate the operation of the production line. Depending on requirements and the level of users’ previous knowledge, various material can be dealt with and reinforced. This includes:

- Production lines of different degrees of complexity
- Structure and mode of operation of a flexible production control system
- Programming of a production control system
- Production databases and production planning systems.
5. Material which you can teach using CIROS® Production

The simulated planning and production processes have a strong didactic quality:
- The production lines are practical and as authentic as possible.
- The facilities for experimentation with simulated computer-integrated manufacturing ensure a close relationship to actual computer-integrated manufacturing, the actual subject of the training. Knowledge is tested and reinforced.
- Realistic experience with the simulated processes creates a new quality of knowledge, turning theoretical knowledge into knowledge proven in applications and industrial practice.

CIROS® Production supports student-controlled discovery-based learning:
- The simulated operation of the production line behaves in the same way as a real production line. Users can thus see immediately whether they have configured and programmed the production line. They can also see the effect of operator error but without causing damage to the production line. Users can thus draw their own conclusions and evaluate these.
- Users can obtain technical documentation for the individual automation stations as necessary. They can also research matters such as the programming methods for production control systems or production planning systems.
- Users can put their knowledge and skills into practice with a variety of possible production lines.
What advantages does CIROS® Production have for teaching?

- CIROS® Production is a PC-supported learning medium and thus offers a different learning method. Teaching can be made varied and motivating.
- Authentic production simulation allows knowledge and skills gained with real production cells or lines to be reinforced and consolidated.
- Virtual production lines offer an opportunity to practice programming a production control system without causing damage.
- Simulated processes can be used to demonstrate and test out conditions which would be too dangerous on a real production line.
- Efficient practical and action-oriented learning is possible even without access to a real production line.
- With CIROS® Production, several simulated examples can be used of a production line of which only one real version is available. This increases system availability for training purposes.
- All the production lines simulated in CIROS® Production are also available as simulated production lines. They thus form ideal complements and combinations for teaching purposes.
- Simulation is the modern tool for training with automated systems and computer-integrated manufacturing.
5. Material which you can teach using CIROS® Production

5.5 Learning scenarios for CIROS® Production

CIROS® Production can be used in basic and vocational training in many different ways. Here are some examples:

- CIROS® Production as an introduction, for motivation, as preparation and as a knowledge database for CIM systems:
  This is valuable for users who have a real CIM system and wish to understand and operate this.
  With CIROS® Production, users have the opportunity to generate a virtual production line corresponding to their real CIM system. They can then use this virtual production line to familiarise themselves with the automation devices and stations within their system. They can obtain the necessary information through on-line help and the on-line assistant. As the control system for a production line can be generated automatically, users do not need any knowledge of the programming of production control systems in this phase. They can simulate production line operation immediately and observe the behaviour of the production line. Depending on their future tasks, users can utilise CIROS® Production to reinforce their knowledge of production planning or programming.

- CIROS® Production as an introduction, for motivation and as preparation for the subject of computer-integrated manufacturing:
  CIROS® Production can be used independently of real systems. On the basis of a library of automation stations, users can plan and generate simple production lines. The typical automation stations available include stores management, robots, CNC machines and transport systems. Users can find information on these devices via the on-line help function and the on-line assistant. As the control system for a production line can be generated automatically, users do not need any knowledge of the programming of production control systems in this phase. They can simulate production line operation immediately and observe the behaviour of the production line. Depending on their future tasks, users can utilise CIROS® Production to reinforce their knowledge of production planning or programming.
5. Material which you can teach using CIROS® Production

- **CIROS® Production as an introduction and a tool for the programming of a production control system:**
  CIROS® Production can be used independently of real systems. On the basis of a library of automation stations, users can plan and generate simple production lines. If users have previous knowledge of the programming of production cells or production lines, they can program sequences for their systems themselves. Programming is carried out using process plans. Process plans can be generated freely or with support from CIROS® Production. As soon as the control system for a production line is available, users can simulate production line operation. This simulation of the production line provides users with an immediate confirmation that they have programmed the production control system correctly.

- **CIROS® Production as an introduction to production planning systems:**
  CIROS® Production supports simple production planning system functions. These include the creation of a new product and associated parts list and the allocation of machines to the production of this product. Product data is stored in a production database to allow automatic production of the product. If users now generate a production line for the desired product, they can simulate and evaluate the production of the product in accordance with their specifications.

- **CIROS® Production as a virtual production line with facilities for process visualisation:**
  For each production line, CIROS® Production automatically generates a visualisation. This consists of a graphical representation of the production line together with a number of central operator functions. This visualisation can be modified using the facilities available in CIROS® Production. In this way, users can learn how to work with visualisation systems. It is also possible via an interface - the DDE interface – to link the production simulation with typical industrial visualisation systems. In this case, users generate a visualisation of the production line on the “external” visualisation system.
6. Example: Planning and simulating the production of a product

CIROS® Production offers you an easy introduction to computer-integrated manufacturing. Using virtual production lines which you generate yourself, you can familiarise yourself with all the working steps from planning to production. The production simulation provides an excellent way of tracking and analysing the behaviour of the production line. The systematic approach which you use for this and the knowledge which you acquire can of course be applied to any other production line, including real ones.

6.1 Learning objectives

These are the learning objectives which you can meet by using CIROS® Production:

Main learning objectives

- Planning and generating production lines for specified products using pre-assembled automation stations and simulating production line operation.
- Understanding and evaluating a virtual production line.

Learning-objective areas

- Understanding the product and the processing technology.
- Understanding the basic structure of a production line consisting of several automation stations. Important automation stations are processing stations, test stations and transport systems.
- Purposeful use of technical documentation for the planning and generation of a production line. Technical documentation is functional descriptions of the automation stations, specifications of the products produced by the stations, data on the process tasks of the stations.
- Graphical generation of production lines using pre-assembled automation stations in CIROS® Production.
- Understanding the structure of a project for a production line in CIROS® Production.
- Automatic generation of a project with a production control system for a production line.
6. Example: Planning and simulating the production of a product

- Familiarisation with a real production line through the associated virtual production line.
- Simulation of production line operation, and drawing conclusions concerning the production process.
- Recognising the advantage of a simulated production process for general industrial operations.

6.2 Methods

The procedure for the planning and simulation of a production line can be described as individual steps. The most important steps are listed below.

The questions which appear opposite the individual working steps offer suggestions and tips as to the precise points which you should study and take into account.

<table>
<thead>
<tr>
<th>Major steps</th>
<th>Questions</th>
</tr>
</thead>
</table>
| Product     | – What product is to be produced?  
              – What is the part number of this product?  
              – What starting workpieces are required? |
| Production process for the product | – What processing technology is required – lathe turning, milling, assembly?  
                                          – What is the production sequence?  
                                          – Is it advisable to arrange the machine in certain order relative to the transport system on the basis of the production sequence? |
| Stations required in order to produce the product | – What machines (resources) are required for the production of the product?  
                                                     – Should the production line be capable of flexible use and thus cover all the major processing technologies? |
| Production line for product | – Where are data and descriptions of the individual stations stored? |
| Project with production control system for production line | – What is the structure of the project with the production control system?  
                                                        – Where is the data on the devices and the structure of the production line stored?  
                                                        – Where is the program for the production control system stored?  
                                                        – Is the program for the production control system complete? |
6. Example: Planning and simulating the production of a product

<table>
<thead>
<tr>
<th>Major steps</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prerequisites for production</td>
<td>– Is all the necessary data available on the product and the production process for automated computer-integrated manufacturing?</td>
</tr>
<tr>
<td></td>
<td>– Is the necessary data entered in the production database?</td>
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<td></td>
<td>– Have the stock contents been correctly initialised?</td>
</tr>
<tr>
<td>Production simulation</td>
<td>– In what mode must the production control system be in order for it to be possible to start production?</td>
</tr>
<tr>
<td></td>
<td>– What methods are available to start production?</td>
</tr>
<tr>
<td>Evaluation / observation of</td>
<td>– What starting workpieces are required?</td>
</tr>
<tr>
<td>production simulation</td>
<td>– Where are the starting workpieces stored - in the automated warehouse or locally on the appropriate station?</td>
</tr>
<tr>
<td></td>
<td>– How great is the depth of production? Are processed workpieces transferred immediately to the next station to allow the next production step to be carried out?</td>
</tr>
<tr>
<td></td>
<td>– When and how are individual production processes started? Can production processes be carried out in parallel?</td>
</tr>
<tr>
<td></td>
<td>– How are the stock contents defined and managed – by the CIROS® Production system or by the user?</td>
</tr>
<tr>
<td></td>
<td>– What conclusions can be drawn from the simulated production process regarding the production sequence?</td>
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<td></td>
<td>– Can the productivity of the production line be increased? If so, by what measures?</td>
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<tr>
<td></td>
<td>– How many workpieces can be managed in the warehouse?</td>
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<tr>
<td></td>
<td>– Are all the storage locations the same, or are there differences, for example in geometrical dimensions?</td>
</tr>
</tbody>
</table>

Systematic approach to production simulation
6. Example: Planning and simulating the production of a product

6.3

Exercise: Planning, simulating and evaluating the production of a baseplate

Exercise

Generate a production line for the production of a baseplate with the part number 42143. The baseplate is made of aluminium and is slightly rounded. Work systematically and use the checklist for general procedure. Simulate production with a test run.

Answer the following questions:

- What processing steps are required for the production of the baseplate?
- What automation stations do you require for production?
- How can the contents of the automated warehouse be defined and tracked?

Method

1. The baseplate with the part number 42143 is an aluminium blank. The necessary holes and the rounding are milled into the blank. Accordingly, the steps required for the production of the baseplate are as follows:
   - Fetch workpiece from warehouse
   - Mill workpiece
   - Return workpiece to warehouse.

2. The following automation stations are required in order to carry out the necessary production steps:
   - Conveyor belt
   - Automated warehouse
   - CNC milling machine.
6. Example: Planning and simulating the production of a product

3. Start Production Simulation in order to generate the production line for the production of the baseplate. To do this, execute the link CIROS® Production Simulation in the program group CIROS® Production in the Microsoft Windows start menu.

4. Activate the command New production line in the File menu. The window Create new production line will open.

5. Select the storage location for the new production line. You can select any directory as storage location.

   Enter the file name. Select CIROS Workcells (*.mod) as the file type, then click on the Save button.
6. Example: Planning and simulating the production of a product

6. A model of an empty production line will open. When a new production line is created, a number of settings are made automatically:
   – The system switches to the **Edit Mode**
   – **Top View** is selected as the view
   – The **Model Libraries** window is opened.
6. Example: Planning and simulating the production of a product

7. First add a transport system. Select, for example, the model **Festo Transport System 6**. To do this, click on the entry **Festo Transport System 6**. The model and a description of this will be shown in a preview. If no data is displayed, click on the **Details** button. Now click on the **Add** button in order to add the selected station.
6. Example: Planning and simulating the production of a product

8. In the same way, add the **Station Stock Single** model.
6. Example: Planning and simulating the production of a product

9. In order to ensure that the working and transfer points are correct during production operation, the models must be appropriately aligned and connected up.

First align the **Station Stock Single** model to the **Festo Transport System 6** model. To do this, click on the red coupling point of **Station Stock Single**. Hold the left-hand mouse button down and drag the coupling point to the bottom left-hand coupling point of **Festo Transport System 6**.

**Station Stock Single** is now connected to **Festo Transport System 6**. The position and orientation of the **Station Stock Single** model will be modified automatically.
10. Now add the Station Mill 55 model. Connect the Station Mill 55 model to the bottom left-hand coupling point of the Festo Transport System 6 model.
11. As soon as your production line has been generated, exit from the **Edit mode**. Change to the View mode to obtain a realistic 3D representation of the production line. To do this, click on the **Edit Mode** command in the **Modeling** menu. The tick next to the **Edit Mode** entry will disappear. You will obtain a 3D view of your production line.
6. Example: Planning and simulating the production of a product

12. In order to obtain a perspective view of the 3D model, select, for example, the **Standard Views/Default Setting** command in the **View** menu. You can use the commands under **View** to move, turn or zoom the view of your production line as desired.
6. Example: Planning and simulating the production of a product

13. Activate the **Create Plant** command in the **Extras** menu. This command saves the production line model as a *.MOD file. Simultaneously, an XML-format interchange file is created which contains the data for the structure of the production line. This interchange file requires the program section **Production Supervision** in order to be able to create the production control system for the production line automatically.

14. The **Save Plant File** window will open. Change to the directory in which the production line model is saved. Accept the suggested file name and click on the **Save** button.

15. Start **Production Supervision** in the **ProjectStudio** mode. To do this, execute the link **CIROS® Production Supervision ProjectStudio** in the program group **CIROS® Production** in the Microsoft Windows start menu.
6. Example: Planning and simulating the production of a product

16. You will see an empty project with the name `Proj.lpj`.

17. Activate the command `Import CIROS Project` in the menu `Extras/ProjectStudio` in order to read in the data for the previously-created production line.
6. Example: Planning and simulating the production of a product

18. In the **Open** window, select the XML file previously created by Production Simulation. The XML-format interchange file and the model file with the file extension MOD are stored in the same subdirectory.
6. Example: Planning and simulating the production of a product

19. After the CIROS® Production project has been opened, a 2D view of the production line will be displayed.

20. Now activate the Setup mode. To do this, select the Setup command in the Project menu.
   The Setup mode must be active in order for you to be able to create or modify project elements. This includes the creation of programs for the production control system.
6. Example: Planning and simulating the production of a product

21. In order to create a production control system automatically, activate the **Generate project** command in the **Extras/ProjectStudio** menu. Respond to the local use question and click on **Yes**. The project with the production control system is saved to the default directory, namely **My Documents**.

22. A production control system has now been created for the production line. You can recognise this by the new entries in the project tree in the **Project** window.

23. Start the **Production** mode in order to simulate production line operation. To do this, select the **Production** command in the **Project** menu.
6. Example: Planning and simulating the production of a product

24. After the initialisation of the Production mode, the visualisation window with operator functions and a display of the process will open automatically.

25. Three production orders are ready-prepared. You can trigger the execution of one of these production orders by clicking on one of the three buttons Penholder, Baseplate and Deskset. Run your mouse over the buttons to discover which products can be produced.
6. Example: Planning and simulating the production of a product

26. Now click on the **Baseplate** button in order to start production of the desired baseplate with the part number **42143**. The button will be highlighted in blue for as long as the order is being executed. You can track production operation in the visualisation window. This displays information such as the process tasks currently being executed or the positions of individual pallet carriers.
6. Example: Planning and simulating the production of a product

27. In the Production Simulation program section, you can observe and evaluate a realistic representation of the production of the baseplate.

28. Once the production order is completed, you can initiate the production of a further product.

Note: In order to execute an order, the production line must include the necessary machines. If a machine is not present, your attention will be drawn to this at the start of production. Try it out and produce a deskset. Moreover, in order to achieve a speedy and fault-free production sequence, the right starting workpieces must be available in the automated warehouse.
6. Example: Planning and simulating the production of a product

29. If you wish to produce products other than those offered via the buttons, use the order tables Orders listed and Orders timed.

30. The contents of the automated warehouse are automatically initialised the first time production line operation is started. You are responsible for the stock contents for further production. The contents of the automated warehouse are managed in the production database.

31. Click on the Database button to open the iCIM Production Manager for the production database. Click on the tab Administration and select the language for the database user interface.
6. Example: Planning and simulating the production of a product

32. Click on the **Stock Contents** button in the tab **Forms** to view the current stock contents.

The specification of a 0 for each storage location means that the workpieces are intended for orders with the order number 0. The prepared production orders in the visualisation window all have the order number 0. The contents of the automated warehouse are thus matched to the production of the prepared orders.

![Image of Stock Contents](image)
6. Example: Planning and simulating the production of a product

33. If you wish to modify the stock contents, you need write authorisation for the production database. Modifications to the production database may be made only by authorised persons and are therefore password-protected. Click on the Login button in the tab Administration. Select the Usertype entry. Then enter the password. If you have not changed the password since you installed CIROS® Production, the default password will still be valid. Once you have logged in as a User, enter under Password: Festo and confirm your entry with Login.

34. You can modify the current stock contents and, for example, overwrite them with the standard presets. To do this, click on the Copy from Stock Init button. You can also modify individual storage locations if particular workpieces are not available.

35. If you wish to cease production operation, deactivate the Production mode. To do this, click on the Production entry in the Project menu. The tick next to the Production entry will then disappear.
6. Example: Planning and simulating the production of a product

6.4 Exercise: Planning, simulation and evaluation of the production of a deskset

Exercise

Create a production line for the production of a deskset with the part number 52675. The deskset is made of aluminium and includes a thermometer, a hygrometer and a penholder and pen. Depending on which workpieces are available in the automated warehouse, either the deskset can be assembled only or the starting workpieces can be produced and used in a second step to assemble a deskset. Simulate production with a test run and analyse the production process. Answer the following questions:

● What starting workpieces are taken from the automated warehouse?
● What workpieces are held in stock locally in the assembly station?
● How great is the depth of production?
● Look at the definition of the production process for the deskset with part number 52675 in the production database. Compare this with your observations of the production simulation.
6. Example: Planning and simulating the production of a product

Method

1. The deskset with the part number 52675 consists of an aluminium baseplate with a slight rounding. The penholder is also made of aluminium and has 5 slots.
   
The processing steps for the deskset are as follows:
   – Milling the baseplate from a blank.
   – Lathe-turning the required number of slots in the penholder blank.
   – Assembling a deskset from a baseplate, penholder, thermometer, hygrometer and pen.

2. The production line for the deskset must include the following automation stations:
   – A conveyor belt, e.g. Festo Transport 6
   – An automated warehouse, e.g. Stock Single
   – A CNC milling machine, e.g. Mill 55
   – A CNC lathe, e.g. Turn 55
   – An assembly station, e.g. Assembly RV-1A.

3. Create the production line for the deskset in the program section Production Simulation.
   To do this, create a new production line with the name Proj_Deskset.
6. Example: Planning and simulating the production of a product

4. Ensure that the Edit mode is active and that the library is being displayed. Use the elements in the library to create the desired production line. Connect the stations to the conveyor belt using the appropriate coupling points.

5. Leave the Edit mode. To do this, activate the entry Edit mode in the Modeling menu. The tick next to the entry Edit mode will disappear.
6. Example: Planning and simulating the production of a product

6. Generate an appropriate 3D representation of the production line. Select, for example, the command **Standard Views/Default Setting** in the **View** menu.

7. Create the plant and the associated XML interchange file for the production control system. To do this, click on the entry **Create Plant** in the **Extras** menu.

8. Now start the program section Production Supervision ProjectStudio.
6. Example: Planning and simulating the production of a product

9. Activate the command Import CIROS Project in the menu Extras/ProjectStudio. Select the required file. The data for the structure of the production line will be read in.

10. After the command Import CIROS Project has been executed, the production control system will have data on the graphical structure of the production line.

11. Now activate the Setup mode. To do this, select the Setup command in the Project menu. You can create and modify project elements of the production control system only when the Setup mode is active.

12. Create a production control system for the production line. To do this, click on the Generate Project command in the Extras/ProjectStudio menu. Respond to the local use question and click on Yes. The project with the production control system is saved to the default directory, namely My Documents.
13. The production control system for the production line has now been created. You can recognise this by the new entries in the Project window.

14. Start the Production mode in order to produce the desired deskset. To do this, select the Production command in the Project command.
6. Example: Planning and simulating the production of a product

15. After the initialisation of the Production mode, the visualisation window with operator functions and a display of the process will open automatically.

16. A ready-prepared production order is offered for a deskset with the part number 52675. Click on the Deskset button to initiate the production of the desired deskset.
6. Example: Planning and simulating the production of a product

17. Analyse the production process either in the Production Supervision visualisation window or in the Production Simulation 3D display. Result:
- The baseplate is taken from the automated warehouse as the first starting workpiece and laid on the conveyor belt.
- Next, the penholder and pallet are taken from the automated warehouse as the second starting workpiece and laid on the conveyor.
- The Station Assembly robot accepts the baseplate and pallet and sets this down at buffer location 1.
- The Station Assembly robot accepts the penholder and pallet and sets this down at buffer location 2.
- The robot transfers the baseplate to the assembly location.
- The workpieces “Thermometer”, “Hygrometer” and “pen” are in stock locally in the Station Assembly.
- The robot fits a thermometer to the first hole.
- The robot fits a hygrometer to the second hole.
- The robot fits a penholder to the third hole.
- The robot fits a pen to the penholder.
- The robot sets the deskset back down on the empty pallet at buffer location 1.
- The robot sets the pallet with the assembled deskset down on the conveyor belt.
- The robot sets the empty pallet used for the penholder down on the conveyor belt.
- The deskset is transferred into the warehouse.
- The empty pallet used for the penholder is transferred into the warehouse.

18. Continue to produce desksets until the stocks of starting workpieces in the warehouse run out. Then observe the production process. Result:
- In response to demand, the missing workpiece is produced and transferred to the warehouse.
- In the next step, the newly-produced starting workpiece is fed to the Assembly Station.
This type of production is also called single-stage production.
6. Example: Planning and simulating the production of a product

19. Now look at the description of the production process in the production database. To do this, click on the Database button in order to open the ICIM Production Manager.
6. Example: Planning and simulating the production of a product

20. Click on the **Production Data** button in the tab **Forms**. The production process for the selected product will be displayed.
6. Example: Planning and simulating the production of a product

21. Select the part number **52675** from the list of part numbers. You will see the associated production process.

   - The deskset is produced by the station class Festo Assembly Station.
   - Any machine of this class is to be used. This is why the entry Resource Class is selected under Resource Type
   - The deskset is produced by the macro process task AsmDeskSet.
   - "ParallelTwo" is entered as the transport strategy. This means that two starting workpieces at a time are fed from the automated warehouse.
   - Starting workpiece 1 from warehouse: Baseplate on pallet with part number 42143.
   - Starting workpiece 2 from warehouse: Penholder on pallet with part number 42104.
   - Locally-stored starting workpiece 1: Thermometer with part number 30000.
   - Locally-stored starting workpiece 2: Hygrometer with part number 30001.
   - Locally-stored starting workpiece 3: Pen with part number 30100.
   - No CNC programs are required.
6. Example: Planning and simulating the production of a product

22. The production process is the formal description of the operations which you can observe during production.
6. Example: Planning and simulating the production of a product