

# Freeze Drying Systems for Non-Sterile Production



Customised Solutions  
Designed & Made in Germany



# Creating value with quality and innovation

Martin Christ Gefriertrocknungsanlagen GmbH is a leading global company that develops and manufactures freeze drying systems, with over 70 years of experience.

Our entire expertise and experience is focused on designing and building customer-specific solutions.

Martin Christ has traditionally focused on customers who want to produce in compliance with cGMP, but not in a sterile environment. Applications in diagnostics, biotech products, inorganic nanoscale materials, and non-sterile pharma make up our core business.

The name Martin Christ is synonymous with comprehensive customer satisfaction around the world. We develop and produce for the highest production standards of plant users. We are also global leaders in innovation. We work continuously to solidify our outstanding freeze drying expertise with our own new developments. Examples include the WTMplus wireless product measurement system, controlled freezing of a batch of thousands of vials within seconds (LyoCoN), and visual process recording, linked to the batch data, with a powerful industrial camera (LyoCam).

Our dozens of corporate patents demonstrate this dedication.



## Specialties are our standard

In the field of non-sterile applications, there is a wide spectrum of products. All the products have one thing in common: they are thermally sensitive and have valuable content, so they can ideally be dried using lyophilisation. Because the preservation step takes place at the end of the process chain, after the final product has already been refined to a great degree, our customers place high demands on the reliability and technical execution of the freeze drying systems.

In the field of diagnostics, more unusual cavities are often used, such as container that consist of two or more individual chambers, deep well plates, or tubes. Christ has great skill here in adapting the base machine and providing the necessary accessories. Examples include the radiation dryer version for when there is not enough contact surface for classic shelf drying, as well as specialized metal forms for complete syringes.



Peptides

Veterinary  
vaccines



Restoration,  
preservation,  
archeological finds, historic  
documents

Collagens for medical  
applications,  
artificial skin



In sterile production, fully automated vial loading and unloading systems are state of the art, with isolators when needed. In the non-sterile environment, however, loading and unloading are often performed by hand or semi-automated, using loading trolleys. We are increasingly integrating automated filling technology and unloading of the dried product, for example using vacuum transport.



Antiallergics



Bacterial suspensions



Food products

Polymers

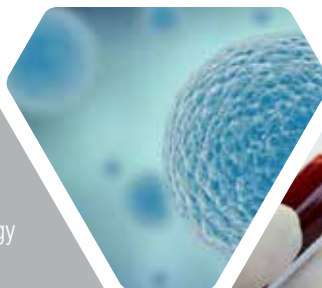


Industrial ceramics

Nanoparticles



Biotechnology products

Diagnostics,  
test kits

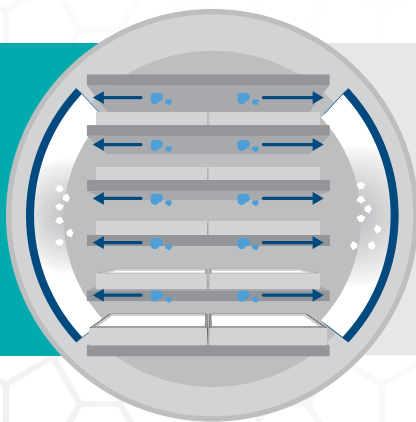
# Unbeatable expertise



## Single-chamber systems

Non-sterile cGMP applications often have special properties and forms that require solutions to be tailored to the customer and their specific case.

We therefore offer freeze dryers based on two different formats, each of which can be specifically tailored to customer requirements. Single-chamber production systems have a cylindrical drying chamber with integrated ice condenser. They make sense when high drying capacity and moderate investment and energy costs are key. The system concept ensures reliable, economical operation for years. With large shelves and variable spacing, the systems can be used universally with high ice condenser capacity. Standard sizes are available with shelf areas between 1.8 and 16.2 m<sup>2</sup> and ice condenser capacities from 20 to 200 kg.



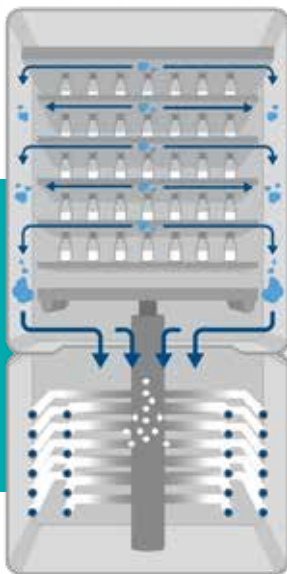
The single-chamber principle is particularly suitable for bulk goods. Examples include bacterial suspensions, nanoscale materials, high-quality food products, and diagnostics.



## Double-chamber systems

In the double-chamber approach developed by Martin Christ, the ice condenser is located directly below the drying chamber. The large, closable opening produces ideal flow cross sections for the water vapor.

The cross sections must be sufficient to handle the enormous amounts of water vapor produced during drying, or the pressure differential between the drying and ice condensation chambers would be too high. The capacity and cost effectiveness of the system is significantly increased, as it operates near the collapse temperature. Particularly temperature-sensitive materials can be dried safely with this system concept. Double-chamber systems have between 1.2 and 40 m<sup>2</sup> of shelf space, with ice condenser capacities between 16 and 500 kg.



The double-chamber principle is perfect for vial and flask drying, as well as for special cavities such as MTPs. Examples include pharmaceuticals, diagnostics, and collagens.

# Overview of system features

## Single-chamber system principle

Shelf areas between 1.8 and 16.2 m<sup>2</sup> and ice condenser capacities from 20 to 200 kg

Ice condenser directly in the product space

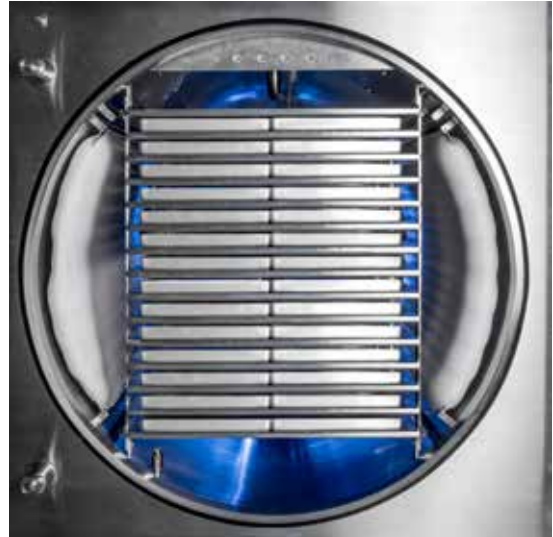
Inexpensive to manufacture

Shelf space for bulk products and special applications that do not require vial closure under vacuum

Compact single-frame construction  
(separate machine frame available as an option)

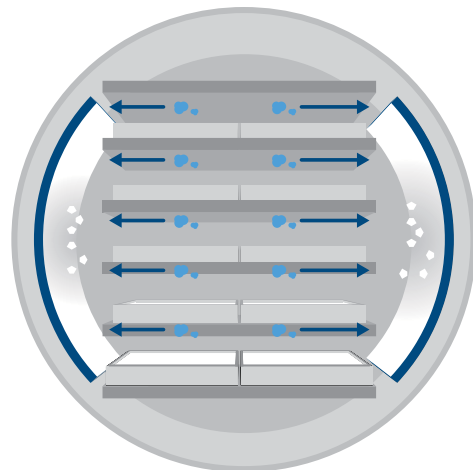
Drying with

- Freezing point determination and process optimisation: LyoControl
- Wireless product temperature measurement: WTMplus
- Monitoring and documentation via camera: LyoCam
- End of drying definition: Comparative pressure measurement



## Overview of benefits

- Simple, uncomplicated, user-friendly operation
- High efficiency and short drying times by locating the ice condenser directly adjacent to the shelves
- Ability to observe product and ice formation on the ice condenser during the drying process and during the defrosting process
- Rapid defrosting of the ice condenser (20–30 min)
- Drying chamber and ice condenser are easy to clean with spray lances or wipe down
- Low maintenance and operating costs
- Space-saving design, easy to transport, simple system setup
- Available with optional electro-hydraulic closure and variable shelf spacing





### Double-chamber system principle

Shelf space between 1.2 and 40 m<sup>2</sup> shelf space, with ice condenser capacities between 16 and 500 kg.

Ice condenser below the product chamber with integrated condenser tank

Ice condenser can be cut off with intermediate valve, for example to run pressure rise tests or to load and unload during defrosting

Shelves are identical for bulk goods and vial closure, with particularly uniform drying when vials are used

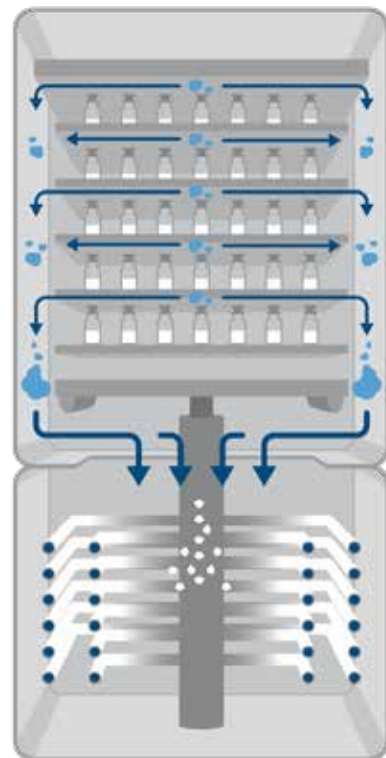
Automatic CIP cleaning (clean in place) available in several versions

Drying with

- Freezing point determination and process optimisation: LyoControl
- Wireless product temperature measurement: WTMplus
- Monitoring and documentation via camera: LyoCam
- End of drying definition: Comparative pressure measurement
- End of drying definition: Pressure rise test
- Manometric product-temperature measurement: MTM

### Overview of benefits

- Ice condenser is simple to control and easy to access via the chamber door
- Easy to clean drying and ice condenser chambers
- Minimal seals to make service and maintenance work easier
- Large cross section between drying and ice condenser chambers
- Nearly zero pressure gradient between ice condenser and drying chambers, so even sensitive and difficult substances with low eutectic or glass transition points can be dried
- Low pressure loss means higher process efficiency and more cost-effective system operation
- Simple validation of your drying processes to fulfill national and international regulations
- Compact system design



# World-class detailed engineering

## Properly sized refrigeration systems to save energy

Production freeze dryers are equipped with up to six independent refrigeration systems, depending on the size of the system. Commercially available piston compressors are typically used.

The entire refrigeration system works mainly on the heat-transfer system to chill the shelves during the freezing process, and mainly on the ice condenser during the drying process, depending on the process segment.

Intelligent energy management across all phases of the freeze drying process balances heat input with the required chilling capacity and leads to low consumption of media.

Refrigeration system redundancy is included as standard in larger systems.

## Optimal vacuum for reliable processes

Our freeze drying systems have rotary vane pumps from leading manufacturers as standard equipment. The vacuum system also has redundant components as standard equipment in large systems. For systems with over 160 kg ice condenser capacity, a Roots pump is used in addition to the rotary vane pump for rapid evacuation times. Oil-free vacuum pumps (dry-running) are also in increasing use.



Engineering area with refrigeration system for several freeze dryers

### Highest quality shelves

The shelves for bulk products, vials, or other vessels are made of high-quality stainless steel. They are welded using state-of-the-art laser welding, with surface roughness of  $Ra \leq 0.8 \mu\text{m}$ . Flatness is  $\pm 0.5 \text{ mm}$  across the entire shelf.

Shelf designs are optimized with FEA, so they are robust but light in weight. Heating and cooling times are reduced. The constant temperature distribution across the shelf and over the entire shelf package is  $\pm 1 \text{ K}$ . This temperature distribution is demonstrated in a standard shelf-mapping procedure as part of acceptance testing in our factory.

The number of shelves is variable, according to customer requirements, the number of drying vessels, and the ratio of total shelf space to ice condenser capacity.



Shelves for bulk drying with fittings for the WTMplus wireless product temperature sensor



Moveable shelves for vial drying with vial closure under vacuum



# Perfect cleaning... a batch winner!

## Cleaning

The freeze dryer can be cleaned manually or automatically using the clean in place, or CIP, process.

### Manual cleaning

Our proven double-chamber design provides very good accessibility through the full-size door to the drying chamber with the shelves and especially to the ice condenser chamber. This optimal accessibility makes manual cleaning easy.

As a rule, the user establishes an SOP for the cleaning procedure. With manual spray-down and wiping, both the freeze drying chamber with shelves and the ice condenser chamber with coils are cleaned the same way every time to meet specifications. This procedure is mainly used in pilot and single-chamber systems.

### CIP procedure for systems with Siemens controllers

The entire drying chamber with shelves, the bellows on the hydraulic cylinder, and the ice condenser chamber with coils are all covered by the built-in conical nozzle system. This fully automated cleaning process has been validated.

With precise positioning of the CIP lines and nozzles, this process produces excellent cleaning results that are validated with a standardized riboflavin test.

Validation of ice condenser cleaning is also an option, due to the patented dual-chamber design with easy accessibility.

The CIP process can be configured in the Siemens controller and runs in flow-through or circulation mode.



Manual cleaning



Automatic cleaning with CIP process



# Decontamination and VHP

## Decontamination

Classic methods here are simple manual disinfection with isopropanol or the like, and steam sterilization typically used in aseptic production processes.

In recent years, the process of decontaminating freeze drying systems by fumigating with VHP (Vaporized Hydrogen Peroxide,  $H_2O_2$ ) has become established in the market.

VHP makes sense particularly when investment costs for equipping the system with steam sterilization are too high, but the benefits of a reproducible process are desired. The freeze drying system is coupled to a suitable VHP generator in a closed circuit, usually via hoses with quick-disconnect couplings. The mobile VHP generator can then be used with other devices as well.

VHP decontamination also has the benefit of shorter cycle times (no heating and cooling phase required) and lower thermal and mechanical loads on the system.



Testing the air in the chamber after the freeze dryer and clean room fumigation cycle

## Strength in specialty solutions

Martin Christ is a leading manufacturer with the experience, flexibility, and skills needed to produce both typical commercial options and customer-specific specialty solutions at any scale.

Some examples include:

- Alternative refrigeration systems, such as LN<sub>2</sub> cooling via heat exchanger or directly in the ice condenser
- Systems designed for drying substances containing solvents, such as reconditioning HPLC fractions
- Drying under sterile conditions, using trays with semipermeable membranes
- Integrated systems for toxic and/or powdered substances
- Extensive PAT tools, including the WTMplus wireless product temperature sensor and comparative pressure measurements
- Manual and automated loading concepts, including filling and extraction of product basins
- Alternative CIP process for dual-chamber systems
- Special configurations for drying books, documents, and archeological finds



Precise volumetric filling freeze dryers for various applications



Large chambers for drying longer objects



Freeze drying of sodden archive materials and documents

# Automation concepts optimized for the application

The Martin Christ automation concept combines leading process automation standards with a focus on freeze drying processes. The result is a finely tuned automation solution for the control system, process visualization, and process data management of the entire system.

Depending on the task, requirements, and complexity, two different control systems can be used. For standard applications, we use the control system that we developed to optimally meet the requirements of freeze drying, the LSCplus.

For more complex needs, particularly when CIP processes are planned, a Siemens S7 controller is used.

Regardless of the controller used, process visualization and documentation are handled by the LPCplus SCADA system that we have developed and programmed specifically to meet the requirements of freeze drying.

Industry standards for process automation, combined with our specialists' decades of experience, produce optimal control systems for freeze drying systems, including communication with external systems from any manufacturer and integration in higher-level automation systems.

Our automation concept has the following essential features:

- Automatic or manual sequencing of freeze drying processes
- Storing a large number of programs
- User support with detailed information on the system and processes
- System controls at several operator stations, for example in the production area, the technical center, and the main control room



# Automation concept – smart and transparent

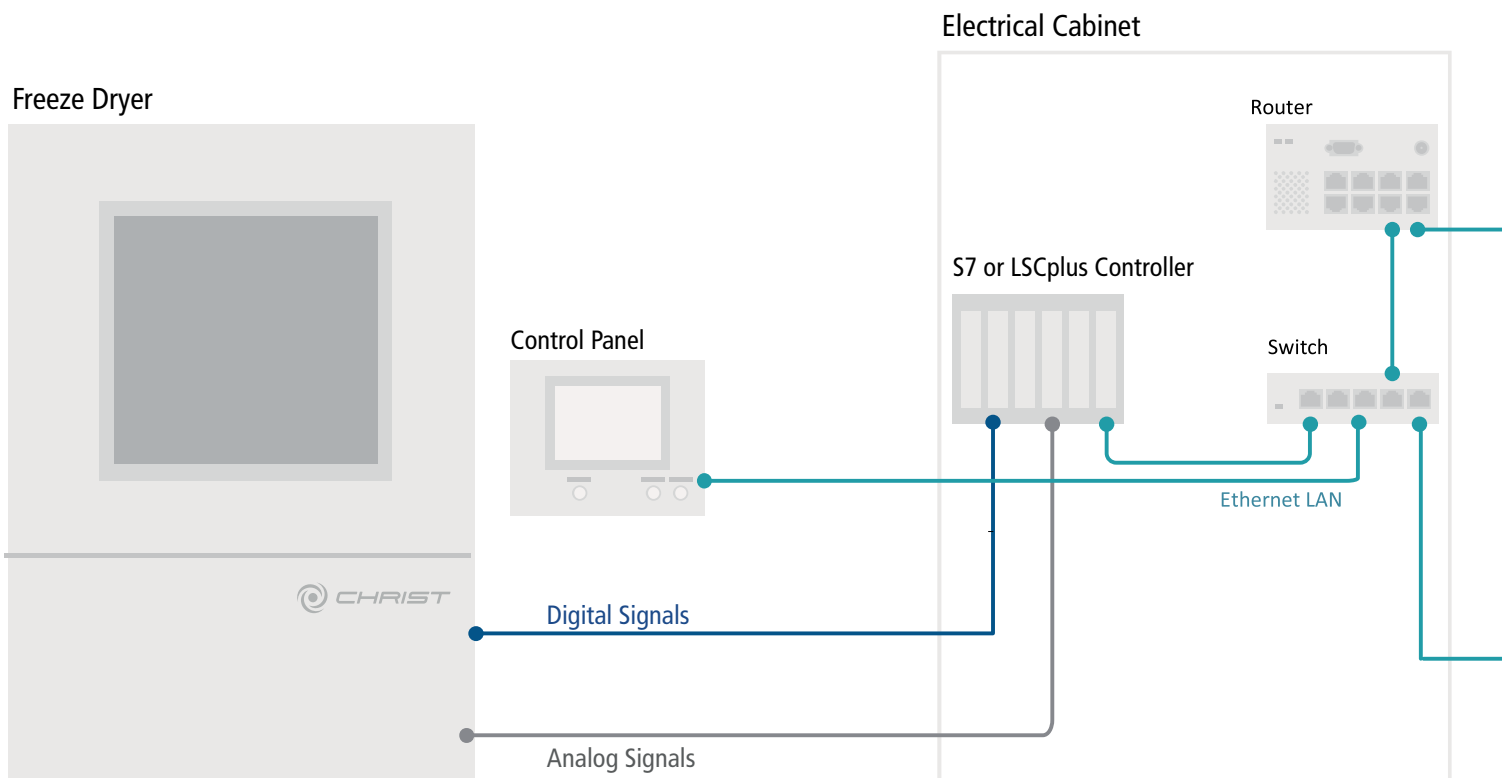
Freeze drying systems commonly require not only comprehensive monitoring of operations, such as for quality assurance. High-end customer products in Martin Christ systems are also optimally protected against batch losses by our fully automated process controls with direct parameter correction.

## LPCplus process visualization

Our user-friendly process and system control systems bundle all of the freeze drying function controls and associated administrative tasks under one uniform user interface. Martin Christ has continued to develop and optimize the LPCplus SCAD software continuously over decades for freeze drying. It includes the following functions:

- Process control for manual, fully automated, and program-controlled drying sequences
- Process visualization
- Process recording (measurement data and audit trail)
- Process documentation and analysis
- Secure data storage
- Administration of freeze drying programs and recipes
- User administration

The LPCplus process control system can be run on Windows-based operating systems. Remote access, such as for maintenance tasks, is also possible. All process steps, including automated cleaning processes, can be configured and executed fully automatically by LPCplus.





### Process visualization specifically for freeze drying

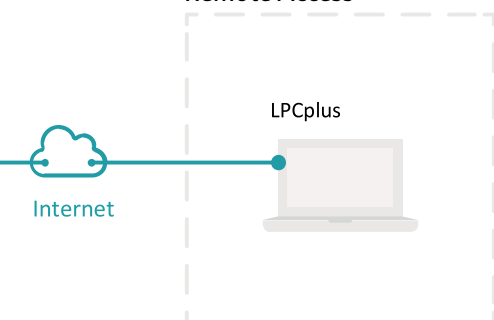
Some highlights of the LPCplus process control and visualization system, which has been continuously advanced over the decades:

- Intuitive system controls
- Context-sensitive help function (integrated detailed operator instructions)
- Optimized for touchscreen and mouse/keyboard controls
- Analysis of several FD sequences with parallel display of process charts and zoom function
- Table of all events and actions in the current process (log book) with filter function
- Graphic-based creation of drying programs (recipes)
- Determines the solidification or freezing point with suggested drying vacuum level
- Prevents unauthorized specification, configuration, and program changes, with plausibility checks via detailed user administration
- Role-based user administration with the ability to connect to a domain
- Optimal data and process integrity, using non-manipulable formats and only one single audit trail.
- The system can be operated from several control stations
- Freely configurable messages and alarms, with available forwarding via email and/or text

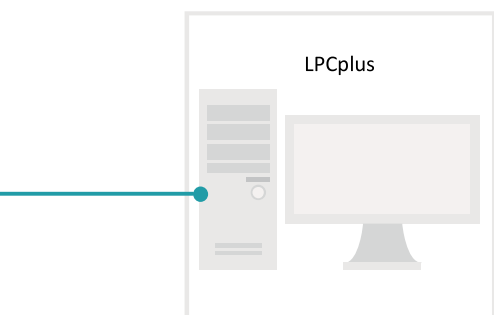


To the video for LPCplus:  
[www.martinchrist.de/LPCplus](http://www.martinchrist.de/LPCplus)

#### Remote Access



#### Control Station



# Process optimization with intelligent PAT tools

## Superior tools for quality assurance and process optimization

The basic equipment level of our freeze drying systems covers many requirements for process monitoring, and can be expanded very easily with options.

All tools are fully integrated in our LPCplus process control and visualization system, so they can be used to control and optimize the process sequence. All data from the process recorder is saved, of course.

### Product temperature

Product temperature is one of the most important parameters for process control and monitoring. Besides the classic, cable-based method with robust PT100 sensors, we also offer wireless WTMplus technology. The use of small, GMP-conforming measurement sensors with no power supply makes it practical to measure product temperature in production batches as well. The measurement data is fully integrated in our LPCplus process control system as well.

### Freezing point

Our LyoRx sensor monitors electrical resistance and product temperature. From the curves of both data points, you can automatically determine the freezing point of your product. This is supported by the LyoControl software module integrated in LPCplus.

### Product resistance

The LyoRx sensor allows automated control of the energy supply to the shelves during the main drying phase. This limits potential melting effects of the product.

### Comparative pressure measurement

The end of the main drying phase can also be deduced by using two different vacuum probes (Pirani and capacitive). When the difference between the pressure measurements falls below a preselected threshold, final drying is started automatically.

### Pressure increase test (double-chamber systems only)

The transition from the main drying phase to the final drying phase can be determined with the aid of the pressure increase test. If the pressure rise in the product chamber with the valve closed remains below a defined limit value, then there is no longer any sublimating ice present in the product and final drying can be started.



Wireless WTMplus product temperature sensors

### LyoCam – greater transparency in freeze drying

Because process times run to several hours, observation of drying is practically nearly impossible.

On the other hand, process incidents that last only seconds or minutes can result in bad product quality. This is where the LyoCam from Martin Christ comes in. A high-end, full HD industrial camera continuously photographs the product at intervals that vary based on the process segment in progress. The behavior of the ice condenser (allocation) can also be documented. The decisive feature, however, is coupling the image to the freeze dryer's LPCplus SCADA system.

A perfect tool for process optimization and quality control.



To the video for LyoCam:  
[www.martinchrist.de/LyoCam](http://www.martinchrist.de/LyoCam)



LyoCam integrated in the front door

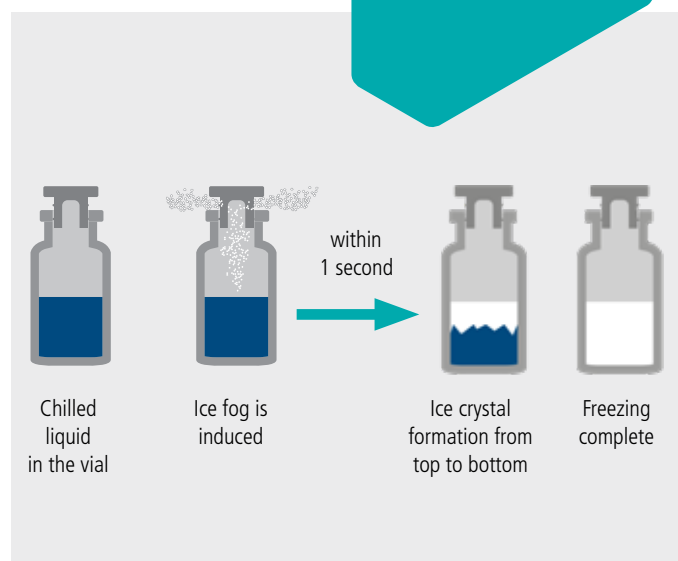
### LyoCoN – Optimizing the freezing process

The freezing process for numerous samples in a freeze dryer is normally a stochastic process. Individual vials crystallize in an uncontrolled manner within a particular time window, such as one hour. This means that the crystallization temperature varies, and therefore so does the ice structure. This affects the subsequent drying phases.

In order to achieve precise freezing of all vials at the same point, Martin Christ developed LyoCoN. Once the freeze dryer has been loaded, ice crystals accumulate on the cold ice condenser from the product itself. At the same time, the liquid product is cooled down to near the freezing point. A slight vacuum is then generated in the freeze dryer. The external container remains at atmospheric pressure. Finally, by opening a valve between the external container and the ice condenser chamber, pressure equalization is induced. The gas is fed past the ice condenser through an injection lance and produces a very fine ice fog in the product chamber, which penetrates into all the vials. These seed crystals immediately initiate homogeneous freezing.



To the video for LyoCoN:  
[www.martinchrist.de/LyoCoN](http://www.martinchrist.de/LyoCoN)



LyoCoN – precise, homogeneous freezing in record time

## We supply applications expertise

We offer holistic solutions. This includes performing drying samples and process optimization with customer products. We also test new detailed solutions available on the market, such as in the field of packaging materials or PAT.

Machines with various levels of performance and equipment are available in our in-house test lab.

If needed, we incorporate qualified specialists from the relevant disciplines, such as pharmaceuticals or biotech.

Holding scientific seminars is a tradition at Martin Christ. We invite outside speakers from a wide range of specialties to share the latest state of the art technology with participants.

Recently we added practice seminars, where participants can train how to work with and on the machines. Qualification and calibration procedures are also practiced.

On request we will also hold in-house seminars at your facility. Let us show you what we can do!



Lab worker extracting samples while the freeze drying process is running



User training in the applications lab



Freeze drying seminar at Martin Christ



## Qualified service for life!

In order to maintain system availability for the entire life cycle of your system, we are continuously expanding our global network of expert engineering and technician partners. Our representatives and partners are regularly trained and certified at our factory.

We work with you to develop a service concept with individualized maintenance and calibration tasks. We provide service for all of our systems in accordance with system-specific logs, thereby minimizing unplanned downtime. We support you in tracking the dates and send reminders when your service contract needs renewal. We check the vacuum seals using high-precision helium detectors and calibrate your process sensors with certified measurement devices. We also check the refrigeration system for leaks in accordance with legal regulations. All of our service technicians have the required certifications of expertise.

If repairs should be needed, we will be on site on short notice. Our cutting-edge, automated high-bay warehouse allows efficient access to all available spare and wear parts. It goes without saying that we use only OEM quality. On request we can ship spare parts via express or direct delivery service.

Our support team is available to answer any questions about freeze drying. We analyze your drying processes and help with optimization using our PAT tools.

If the life cycle of your freeze drying system has come to an end, we can provide economical alternatives to a new system with modernization of the system technology (retrofits), as well as upgrades and software updates.



Maintenance & calibration

Spare parts



Modernization & upgrades

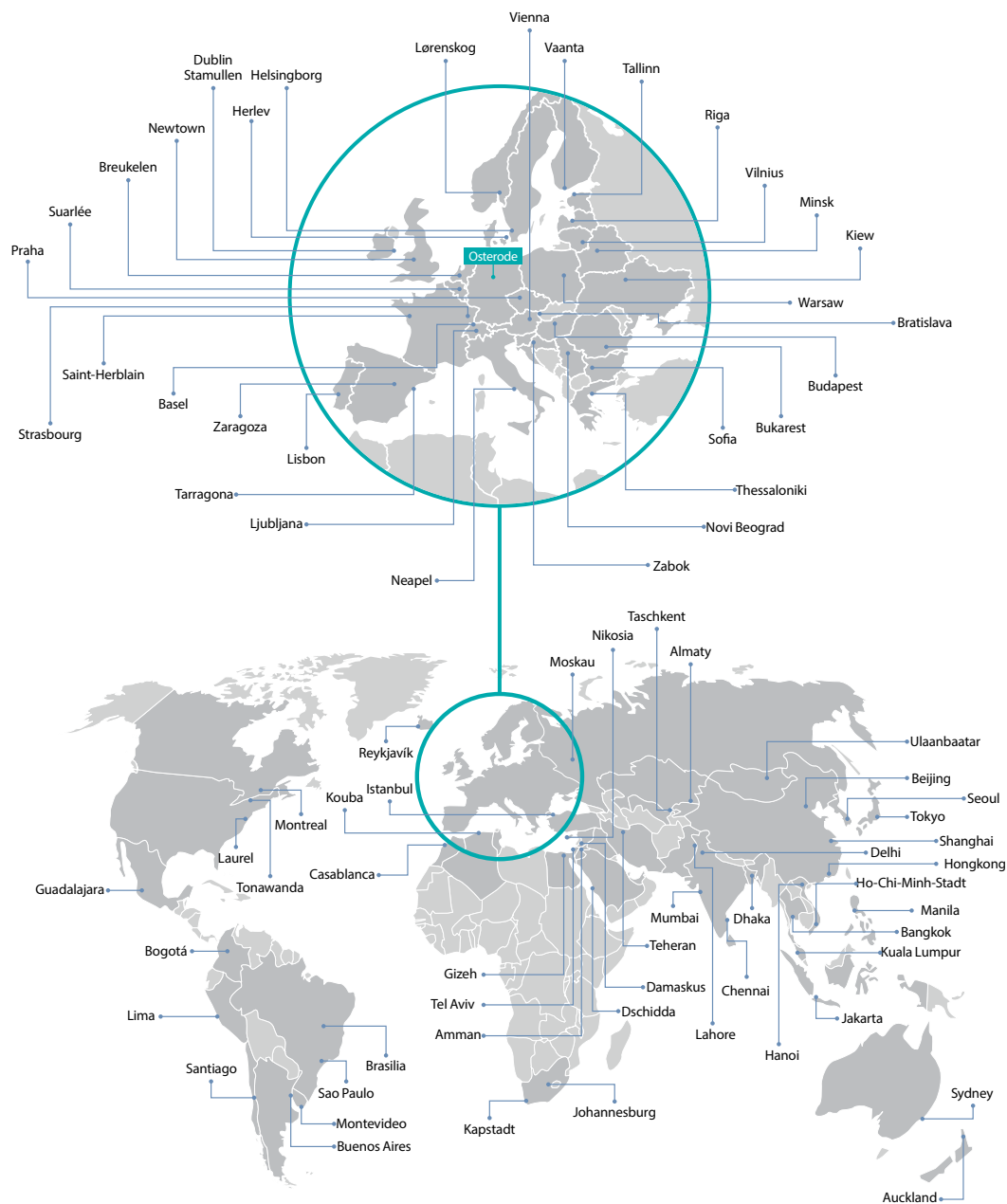


Consultation & training



# Global service for local production reliability

Our systems are operating successfully in over 70 countries around the world. An international network of partners is available for service and qualification work. Our specialists can also be engaged quickly around the world, either remotely or on site in person.



## Selected locations of our representatives.

An overview of all representatives with detailed contact information can be found at [www.martinchrist.de](http://www.martinchrist.de)

## Our product range

With our unique, broadly graduated range of devices of accessories, we provide freeze drying systems and vacuum concentrators for any application. Challenge us to support your task!



- ① Freeze drying systems for industrial production, with ice condenser capacities from 20 to 500 kg; individualized project planning including the LyoShuttle loading and unloading system.
- ② Pilot freeze drying systems for process development and optimization, with ice condenser capacities from 4 to 16 kg.
- ③ Freeze drying systems for routine applications, research, and development, with ice condenser capacities from 2 to 24 kg.
- ④ Rotary-vacuum concentrators for routine applications, up to evaporation in high-end pharmaceutical research.



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