

BATCH & CONTINUOUS DRYING



HOSOKAWA MICRON B.V.

PROCESS TECHNOLOGIES FOR TOMORROW

PROCESS FOR TECHNOLOGIES TOMORROW

ABOUT HOSOKAWA MICRON B.V.

Hosokawa Micron B.V. is specialist in the design, manufacture and supply of powder processing systems and equipment for the mechanical and thermal processing of dry and wet powders. Located in Doetinchem in the Netherlands, Hosokawa Micron B.V. is expert in mixing, drying and agglomeration.

Hosokawa Micron B.V. was established in 1987 as a result of a merger between Nautamix in Haarlem (founded in 1923), Machinefabriek Vrieco in Zelhem (founded in 1939) and ISEM in Doetinchem (founded in 1928). In 2000 Schugi in Lelystad (founded in 1954) was merged into the company. Today, Hosokawa Micron B.V is one of the main companies within the Hosokawa Group.

MISSION STATEMENT

Hosokawa Micron B.V. is a leader in offering technological know-how and solutions in the field of mixing, drying and agglomeration. By our professionalism, service orientation and dedication we help clients to achieve their goals, or even exceed them. In doing so we achieve long-term relationships with both clients and suppliers as well as an attractive return for our shareholders.

We offer a challenging and motivating work environment for our employees and want to contribute to a sustainable society.



Mixing
Drying
Agglomeration

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Food
Pharmaceuticals
Chemicals
Minerals & metals

DRYING TECHNOLOGIES

SELECTING THE RIGHT DRYER

When selecting the right drying equipment, it is important to take a number of factors into account. There are the properties of the feed material to consider, like moisture content, consistency, particle size and distribution, temperature resistivity and porosity. The quantity of the feed material is also important and will help determine the need for batch or continuous operation. Moreover, for products that are toxic, explosive or run the risk of oxidation, there is a need for closed-circuit operation.

Additional factors to consider include specific requirements for final product quality, size, shape and moisture content; the production environment, the permitted construction materials, the availability of energy resources and energy consumption.

Hosokawa Micron B.V. is certified according to the international standard NEN-EN-ISO 3834-2 for welding. The ISO 3834 quality standard applies to all activities in the field of welding and covers the entire welding organisation.

Make the most of our expertise and make selecting the right dryer, easy.

CHALLENGE US TO SOLVE YOUR

GREEN EFFICIENCY!

With the effects of global warming and pollution on energy prices and the environment, saving energy is becoming ever more important. In fact, the best way to save energy is by drying the feed material mechanically using, for example, filtration, centrifugation or sedimentation. This will remove as much of the solvent as possible before starting the thermal drying process.

The next stage is to select a thermal drying process that uses a minimal amount of energy and one that takes energy recovery into account using heat pumps, vapor flow recompression or superheated steam for example.

Hosokawa Micron can help you select the right drying process to do just that: save energy. Our experienced engineers are more than happy to give you the advice you need.





DRYING PROBLEMS!

Agrochemicals
Flavours **Ceramics**
Polymers **Metal powders**
Food ingredients
Injectables **Bulk pharmaceuticals**
 Mineral fillers
Catalysts

Micron Dryer & Drymeister-H

Hosokawa Micron's flash drying technology has been developed to combine drying, de-agglomeration/milling and classifying technology in one piece of equipment. The Micron Dryer flash dryer (MDH) is in continuous development and was the first drying system of its type to be patented worldwide. The latest version of this flexible drying technology is the Drymeister® (DMR-H), a state of the art technology.

Its unique design makes it suitable for drying numerous different materials with a wide range of different properties. It can handle fluctuating moisture content from a few per cent to more than 80 per cent. The Drymeister-H is ideal for:

- Suspensions
- Slurries
- Pastes & dough
- Filter cakes
- Wet powders

Key benefits of this unique technology are its efficiency, reliability and low maintenance/operational costs. Moreover, it can be used to achieve different fineness varying from D97 = 250 µm down to D50 in nm in the case of wet milling, depending on the upstream process. In combination with wet milling, the Drymeister-H is able to produce extremely high-end fineness.

Working principle

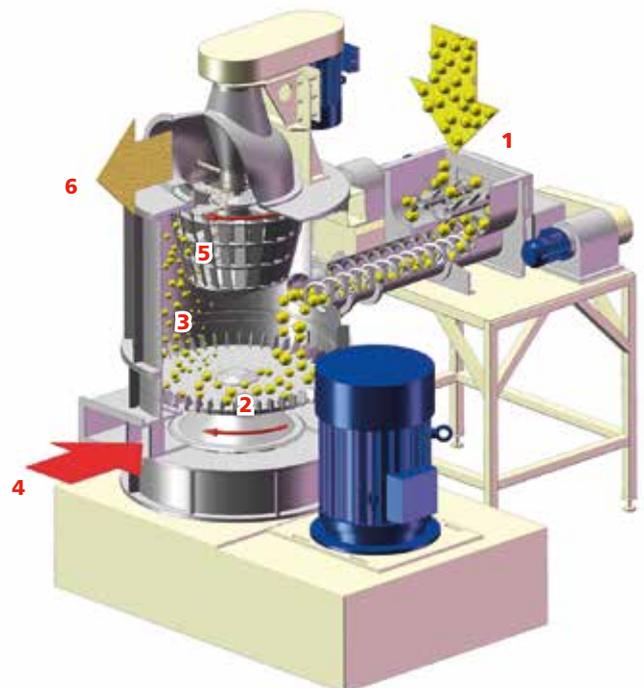
The wet material is fed through different specially-designed feeding systems (1) into the grinding (2) and drying (3) sections of the dryer's main body. The impact energy imparted by the grinding rotor disperses the wet material into very fine particles.

A temperature-controlled, hot, gas stream coming from the air heater (4) is drawn by the exhaust fan through the main body and fluidises the fine particles in the grinding chamber. This guarantees optimal heat exchange and instant evaporation of moisture.

The dried particles are conveyed with the gas stream to the top section of the dryer where a separator (5) classifies the particles by weight. Particles which are too coarse or too wet return to the lower sections. Particles passing the classifier at the set cut point are conveyed with the exhaust air (6) to a powder-air separating system like a cyclone or cyclone filter in combination with cyclone scrubbers for example.

A fluidised bed of product in the drying chamber ensures a low level of adhesion of un-dried material on the inside wall of the drying chamber.

By changing process parameters like the classifier speed, the outlet temperature, the moisture content and the particle size of the end product can be adjusted and controlled.



Flash drying Technology

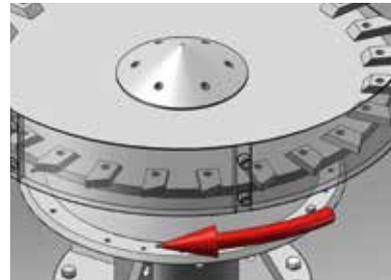


Model types

The main difference between our different flash dryer models is situated in the dispersion/milling section. Depending on the texture of the feed and the required final product properties, various dispersion mechanisms can be used. The three most important ones are:

1. Drymeister-H Bar-Disc type rotor

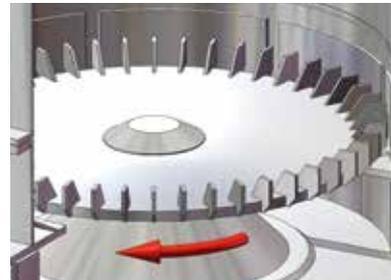
A strong impact and air turbulence is generated by a high speed dispersion rotor, called the bar-disc rotor: with a maximum tip speed of 110 m/s. This rotor is used for drying more solid materials with moisture such as filter cake.



Bar-disc rotor

2. Drymeister-H Blade type rotor

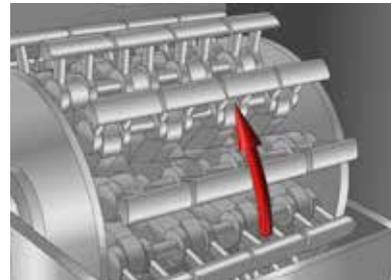
This rotor is used to handle sticky and more liquid dispersions. The rotor ensures a perfect dispersion of the feed material into the hot air stream.



Blade rotor

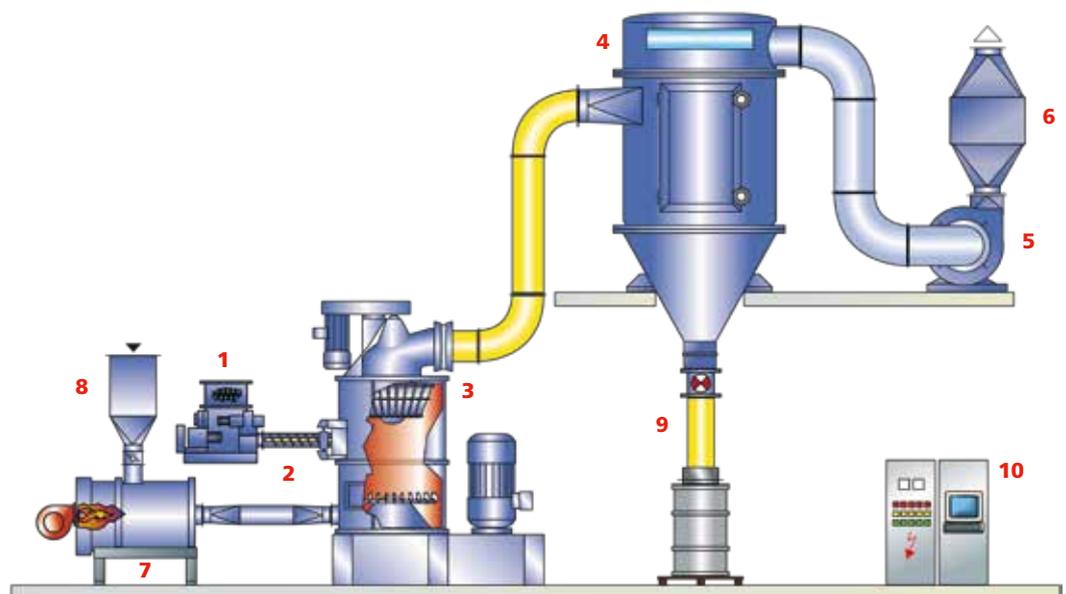
3. MDH type rotor

A horizontally driven grinding rotor with TT hammers takes care of a combination of milling and drying. The impact on the particles is significantly higher compared to the Drymeister-H.



TT hammers

- 1 Product in / agitated hopper
- 2 Dosing screws
- 3 Drymeister-H
- 4 Filter
- 5 Fan
- 6 Silencer
- 7 Direct heater
- 8 Inlet filter
- 9 Product out
- 10 Control cabinet



Flow sheet of an open flash drying system

Typical Processes/Applications

Our flash drying technologies are suitable for a large variety of applications which in turn means an extensive number of factors to take into consideration when selecting the right type: product consistencies, nature of the raw materials: particle size distribution, moisture content etc.; the liquids to be evaporated, temperature and so forth. This is why we like to work closely with our clients to find out what would be the most suitable flash drying system for you.

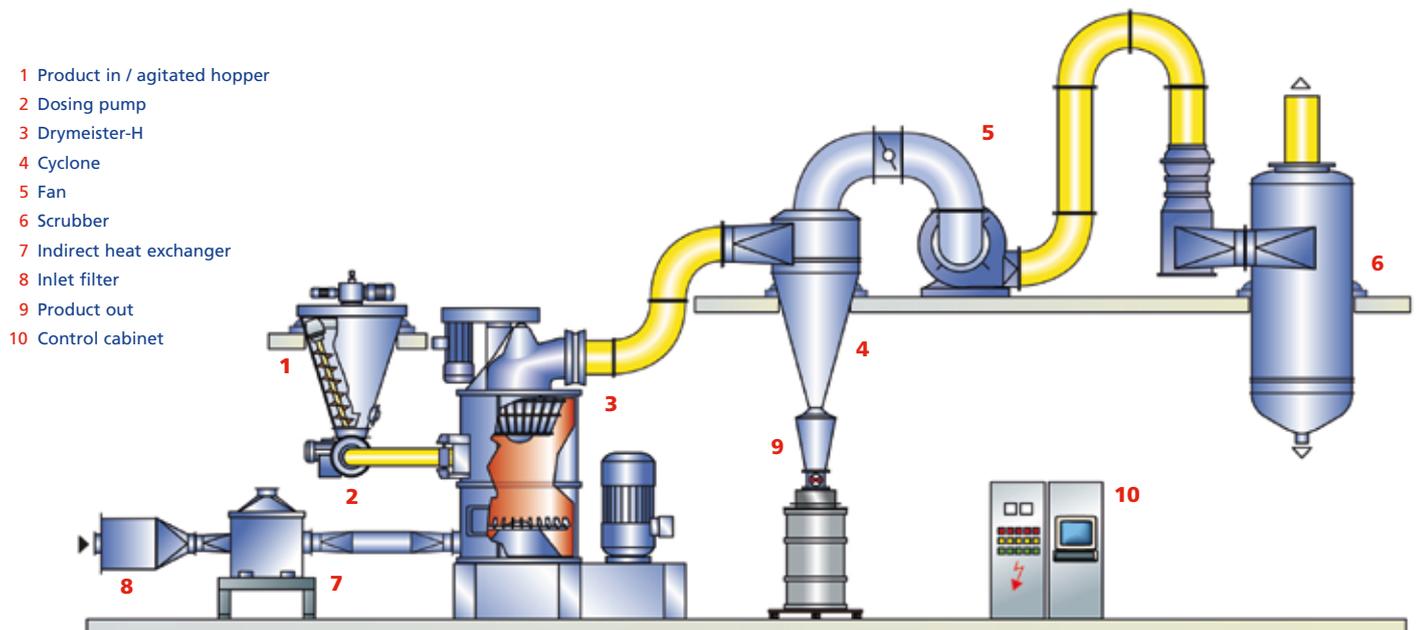
Using our practical engineering expertise and process know-how, we can design and engineer the perfect continuous flash drying system to meet your specific process and end-product requirements.

Below you will find two examples of process applications, one open and one closed system, and considerations that need to be taken into account when selecting a flash dryer:

1. Open system (drying food)

Organic materials used in food often require special processing systems to handle their specific characteristics. Safety aspects due to the risk of explosion and/or auto-ignition need to be taken into consideration during the engineering of such systems. In addition to the risks related to the handling of such products, hygienic design and construction aspects are essential.

Depending on the final use of the dried powders, bacteria levels have to be kept under control. This might require the engineering of wetting or cleaning-in-place systems as well.



Human food grade flash drying installation for organic / thixotropic materials



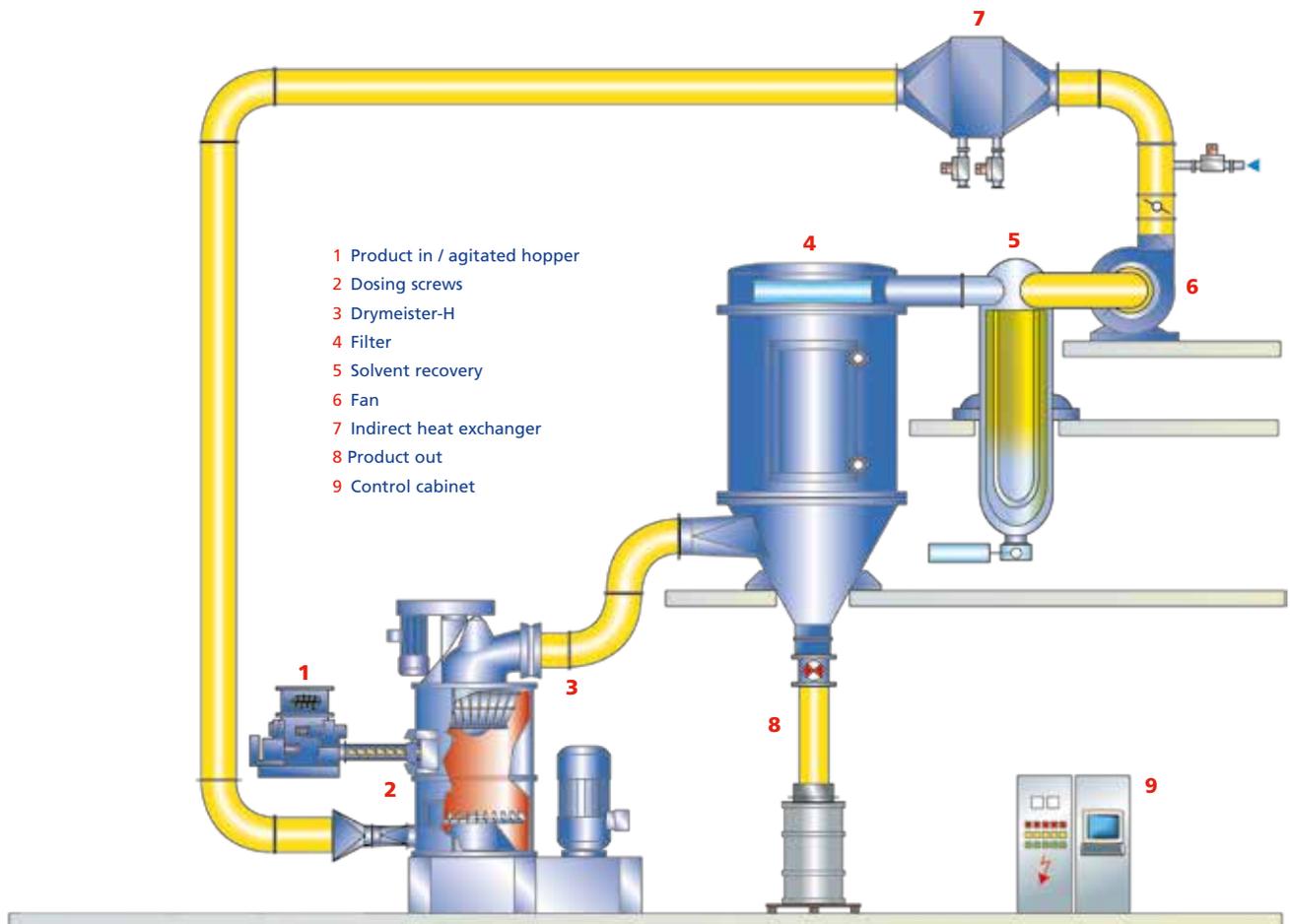
2. Closed system (drying chemicals in inert gas atmospheres)

When chemical materials that are explosive or contain solvents for example have to be processed, the Drymeister-H can be designed to operate using an inert atmosphere. When operating using an inert gas or a closed loop system, we can also evaluate the benefits of a heat recovery system.

Operational costs of drying systems are of high importance especially when you are processing low-cost products. It can be economical to recover the heat contained in the outlet gas from the fan, in order to reduce the plant's operational costs.

Several heat recovery systems can be applied depending on the process conditions:

- Gas/gas heat exchanger
- Warm gas directly re-introduced to the burner
- Warm water production



Chemical flash drying installation for materials containing solvents

Complete systems

Hosokawa Micron has been installing its Micron Dryers and Drymeister-H flash drying systems all over the world for more than 40 years. Extensive experience and know how of drying processes enables us to design, manufacture and install complete drying systems, as well as all of the necessary ancillaries. Below you will find an overview of some key system components.

1. Feeding systems

Feeding a dryer is an integral part of the drying system, ensuring a constant feed rate. Hosokawa Micron offers reliable feeding systems to ensure optimal efficiency of the drying process and excellent end-product consistency.

Typical feeding systems:

Screw feeders

This type of feeder comes in several variations, for example: single or double shaft with full or open flights, paddle or ribbon; heated versions are also available for materials with a dough-like consistency.



Pumps

The type of pump depends on the application; e.g.: screw, diaphragm or hose. The feeder itself is often combined with a feeding hopper.



Static feed hoppers

These are designed to handle product with easy-flowing characteristics and are available in a wide range of dimensions. These feeders can also be heated to increase the drying efficiency, to improve the feeding or to avoid bacterial growth when working with food.

Agitated feed hopper

Specially-designed feed hoppers with various agitators guarantee a constant feed of wet material above the feeder for accurate feed to the dryer. For larger volumes or thixotropic feed materials for example, we would recommend specifically-designed screw cone hoppers.





2. Heating systems

A gas heater is necessary for the supply of hot gas to the dryer. The heater includes a temperature control system to maintain a constant gas temperature at the dryer outlet. Types of gas heaters we would recommend are:

Direct heaters (up to 650°C inlet)

- Gas burner
- Oil burner
- Electric heater
- Hot gas from other sources

Indirect heaters (up to 450°C inlet)

- Steam heat exchanger
- Thermo-oil heater
- Indirect gas heater

It could be worthwhile considering a combination of heat sources depending on your site utilities or your global location. Typical combinations are:

- Steam + oil
- Steam + electric

It is possible to filter incoming heat media before heating, using different types of filters. This will provide clean process gas when it is required.



3. End product recovery

There are several solutions to choose from for collecting the fine powder after drying. Product characteristics like fineness, density, temperature, explosivity/flammability and process parameters like the material/gas concentration are important considerations when selecting the right solution.

• Filter

The simplest solution is when the product and the gas go directly into the filter.

• Cyclone + filter

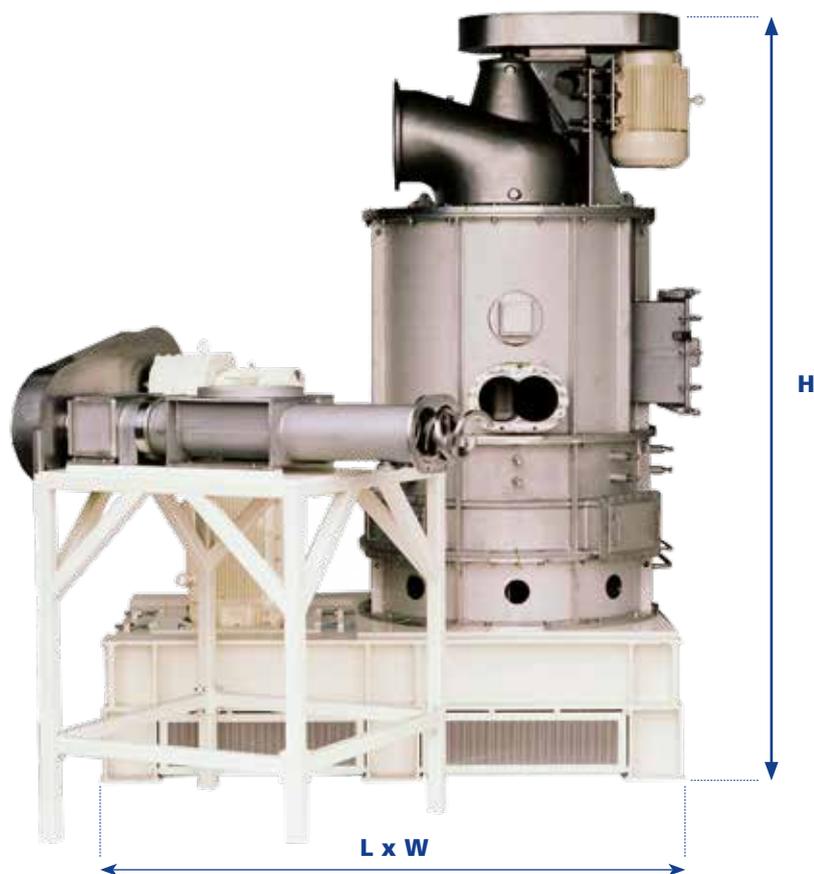
When cleanliness is important we recommend adding a powder-air separating system like a cyclone before the material/gas mixture is conveyed into the filter.

• Scrubber

When handling organic materials where auto-ignition is a risk, we recommend adding a wet scrubber after the dry filter.



Drymeister-H models and evaporation capacities



Flash drying Technology

Models & specifications

Hosokawa flash dryers are available in several models. A number of models with their typical characteristics are described below. Please note that these values are indicative only. Detailed information on all models is available on request.

Model	[-]	DMR-1H	DMR-2H	DMR-3H	DMR-4H	DMR-5H	DMR-6H	DMR-7H
Height (H)	[mm]	1940	3000	3300	3600	4500	5000	5500
Length (L)	[mm]	1400	1700	2300	2400	3600	4500	5000
Width (W)	[mm]	700	1200	1500	1600	1600	2600	3200
Max. power grinding motor	[kW]	11	22	45	90	200	280	355
Min./max. power separator motor	[kW]	0.75/4	1.5/11	2.2/15	5.5/30	11/45	22/55	30/75
Max. volume outlet air 80 °C	[m ³ /min]	25	50	100	200	400	600	800
Evaporated water at ΔT=150 °C	[kg/h]	79	158	316	632	1264	1896	2528
Evaporated water at ΔT=200 °C	[kg/h]	103	206	412	824	1648	2472	3296
Evaporated water at ΔT=300 °C	[kg/h]	148	296	592	1184	2368	3552	4736
Evaporated water at ΔT=400 °C	[kg/h]	189	378	756	1512	3024	4536	6048
Evaporated water at ΔT=500 °C	[kg/h]	226	452	904	1808	3616	5424	7232



Key features

Easy access

Either for cleaning, inspection or maintenance inside the dryer, the Drymeister-H offers the best accessibility, whatever size you may choose.



Ultra fine regular end product

Due to its specially-designed dispersion rotor, the Drymeister-H is able to produce fine or ultra-fine powders in one step from suspensions, slurries, pastes and dough, filter cakes and wet powders.



High evaporation capacity

Due to the combination of high ΔT with a good dispersion of the wet product in the gas, the Drymeister-H can evaporate large quantities of liquid, such as water.



Low energy consumption

Open loop, closed loop or gas recycle system: depending on the chosen system, various levels of energy savings can be achieved.



Efficiency Reliability
Compact design
High evaporation capacity
Low maintenance
Extremely high end fineness

Vacuum Dryers

Drying is responsible for more than 15% of the energy used in modern industrial processes. This makes energy efficiency a major factor to be considered when designing a vacuum drying system. At Hosokawa Micron, we are expert in the development of such state-of-the-art drying technologies and put a lot of thought into developing systems that save you energy.

When it comes to our vacuum drying systems, we have technology that is capable of handling materials such as wet powders, filter cakes, pastes and slurries, especially those products that are heavy, sticky, heat sensitive; that contain solvents, are toxic or even explosive. Our vacuum dryers are suitable for low vacuum operation and can also be applied to other phases in the process, for example:

- Reaction/crystallisation
- Heating/cooling
- Sterilisation
- Liquid/solid separation and de-aeration

Our Nauta® conical screw vacuum dryer was one of the first agitated vacuum dryers developed and was designed to replace the vacuum tray dryer. Now we have an even broader range of vacuum drying systems for the treatment of an even wider number of media, from chemicals and metals to pharmaceuticals.

Working principle

1. Heat energy is transferred into the product through a jacketed vessel wall causing solvents or moisture residues to evaporate.
2. A rotating agitator (e.g. screw, ribbon or paddle) transports the product along the vessel wall and helps the vapours to escape to the surface providing a frequent exchange of particles in contact with the heated surface at the same time.
3. A vacuum system keeps the vessel under constant vacuum and removes the vapours from the vessel, having separated dust particles from the vapours in a dust filter on top of the vessel first. The vacuum within the vessel also reduces the saturated vapour pressure of the solvent, facilitating drying at much lower temperatures.
4. For recovery of solvents, a condenser can be installed in combination with a collection vessel. The drying time and the drying process are dependent on heat conduction of the solid particles and solvents, pressure and temperature conditions as well as the speed of the agitator.



Conical screw dryer



Conical paddle dryer

Vacuum drying Technology



Choosing the right agitator

One of the most important design aspects of a vacuum dryer is its agitator. In order to choose the right agitator with the right characteristics, it is essential to understand what the properties of the feed material are and what you expect from the vacuum drying process.

Screw agitator

The screw agitator is a well-proven design suitable for drying powders, filter cakes, pastes and slurries under atmospheric or vacuum conditions. It is suitable for almost all products even when they are sticky. With its excellent product transportation along the vessel wall, it guarantees an efficient drying cycle and can be applied for dryers with capacities of over 20 000 litres.



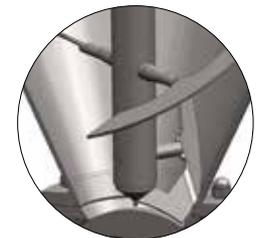
Screw agitator



Ribbon agitator

Ribbon agitator

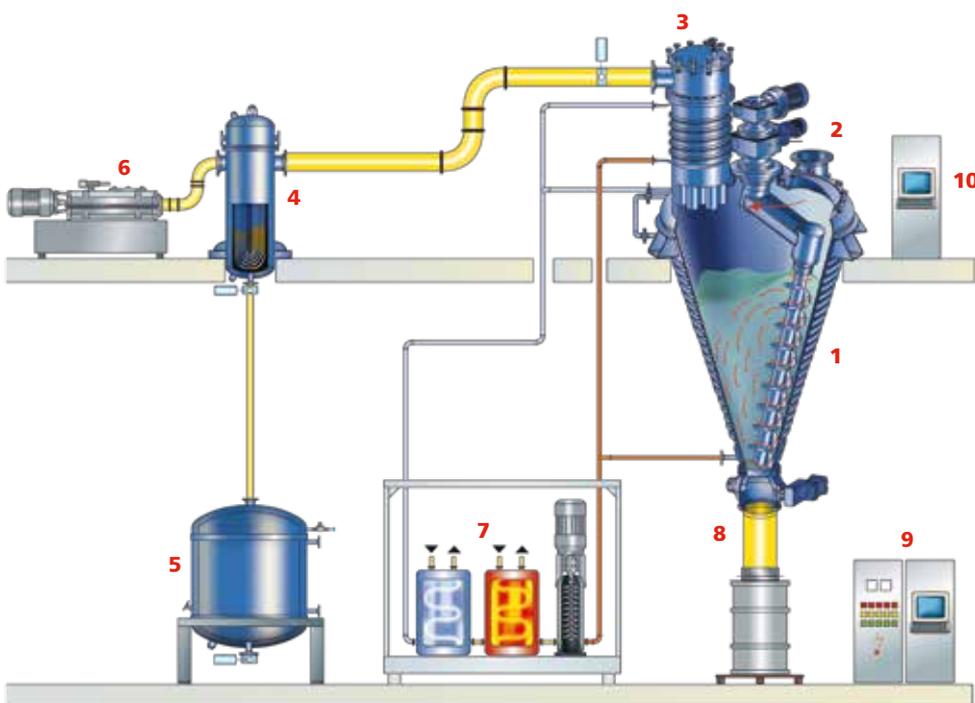
When products have low-starting moisture content and good flow, a ribbon agitator can provide an alternative solution to the screw agitator. It can agitate a larger batch at any one time, resulting in better heat transfer and possibly shortening drying time.



Paddle agitator

Paddle agitator

When products are not likely to stick, a paddle agitator can be used to provide optimal temperature control and to transport product between the rotor tip and the vessel wall. When required, it can also be used to mix the products intensively after the drying cycle.



- 1 Vacuum dryer
- 2 Product in
- 3 Vacuum filter
- 4 Condenser
- 5 Receptacle
- 6 Vacuum pump
- 7 Heating/cooling skid
- 8 Product out
- 9 Control Cabinet
- 10 Operating Panel

Vacuum drying installation with one condensation step

Typical Applications

Using our practical engineering expertise and process know-how, we can design and engineer the most suitable vacuum drying system to meet your process and end-product requirements. Below, you will find two examples of typical applications, followed by an example of Hosokawa Micron's continuing Research & Development for its vacuum drying technologies.

1. Vacuum drying in the chemical industry

Drying at low temperatures and deep vacuum levels in the chemical industry is becoming more and more important due to increasingly stringent requirements. Chemical products like polymers, pigments, toners and agro chemicals are produced in large quantities and capacities, which need to be dried under vacuum conditions and are often heat sensitive. This means that hotspots, localised heat input, bearings or localised structural supports inside the vessel need to be avoided.

Hosokawa Micron has invested in continuing research and engineering for the development of vacuum vessels and agitators for this kind of application. The sizes of the vacuum dryers we can fabricate is always growing and we work with cantilevered agitators that are no longer supported at the bottom of the vessel. This improves the flexibility of our dryers even further when it comes to handling slurries, pastes and powders to low end-moistures.



Smart engineering:

In the last couple of years, Hosokawa Micron has developed their vacuum dryer in a multi-purpose piece of equipment capable to perform much more tasks than only drying at low temperature.

Different chemical and crystallisation reactions as well as thermal and/or pressure treatments such as steam stripping and vacuum sterilization are being performed in vacuum dryers.

In some cases, solid/liquid dewatering can be realised prior to a drying stage. This can be of interest to improve the cycle efficiency. This step is possible by installing dewatering filters in the outlet valve or in the vessel depending on the product characteristics.



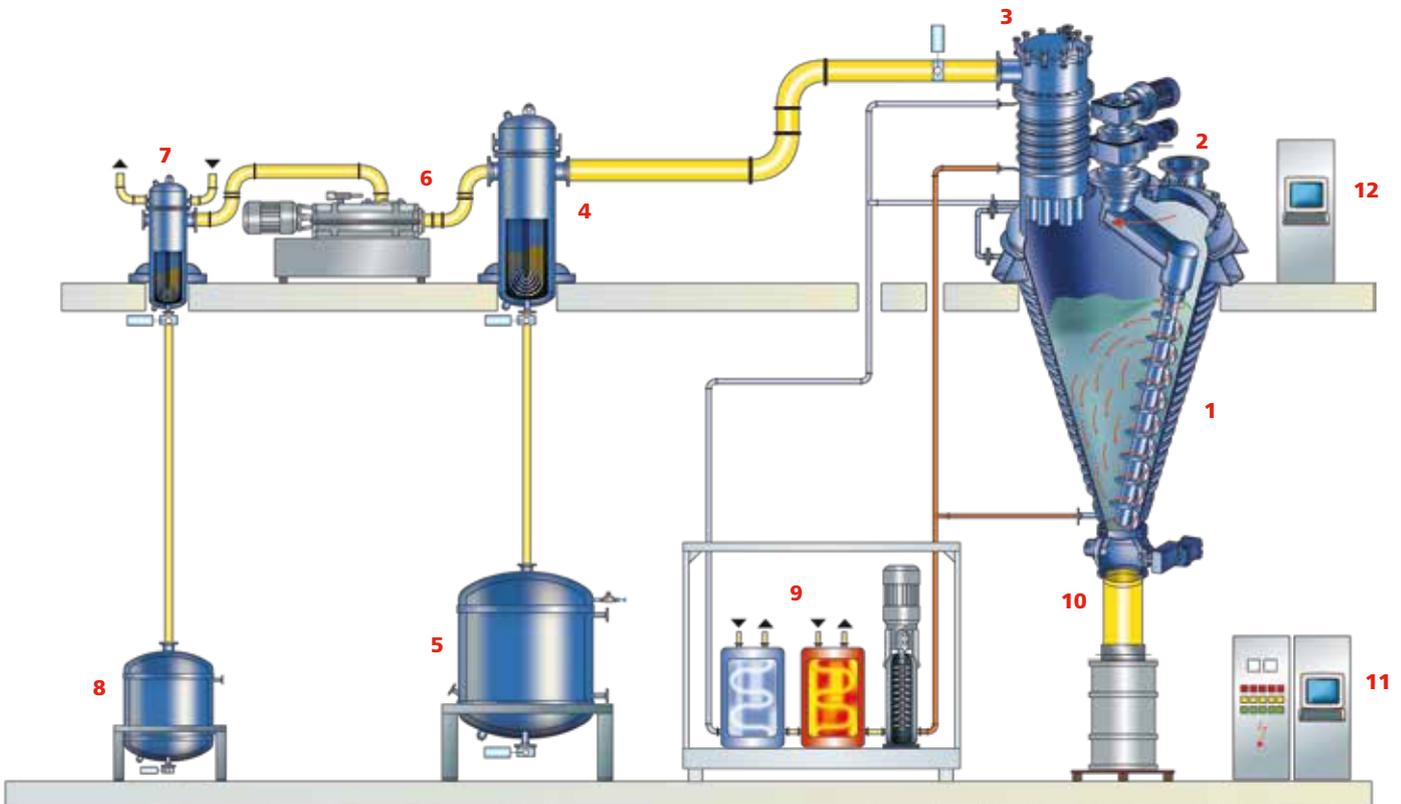
2. Aseptic and sterile process in the pharmaceutical industry

When dealing with active pharmaceutical ingredients, equipment needs to be sterile and aseptic. Our dedicated pharmaceutical department has extensive experience with the requirements set by pharmaceutical concerns, and can provide expert guidance for the design and engineering of your dedicated processes.

Some aspects should be looked at very carefully taken into account how critical they can be:

- Design of flanges and static seals
- Design of dynamic seals like mechanical seals
- Design and concept of sampling
- Battery limit and separation of sterile/aseptic - non sterile environment
- Sterilisation philosophy and validation

Recovery of condensate and control of temperature at all critical spots inside the process.



Vacuum drying installation with two condensation steps

- | | | |
|-----------------|-----------------------|------------------------|
| 1 Vacuum dryer | 5 Receptacle | 9 Heating/cooling skid |
| 2 Product in | 6 Vacuum pump | 10 Product out |
| 3 Vacuum filter | 7 Optional condenser | 11 Control Cabinet |
| 4 Condenser | 8 Optional receptacle | 12 Operating panel |

Complete systems

Hosokawa Micron has been installing vacuum dryers and vacuum drying systems all over the world for many years. This extensive experience and know-how makes us experts in the design, manufacture and installation of complete drying systems, including all of the ancillary equipment imaginable. Here are some of the key components that we engineer and manufacture.

1. Heating / cooling skid

Hosokawa Micron uses the latest advanced 3D drawing software for engineering skids for indirect heating and cooling of our vacuum drying systems. With these kinds of skids, it is possible to heat or cool the complete dryer and to cool the ancillaries, like condensers. When required for reflux processes, the top section of the dryer can be cooled at the same time as the bottom part is being heated.



2. Condenser / vacuum skid

To avoid large vacuum pump systems or too many solvent emissions, a condenser is placed in combination with a receptacle. The condenser can be placed before and/or after the vacuum pump, depending on the liquid to be evaporated. Different types of condensers can be used. Plate exchangers are a good choice considering their heat transfer and volume and hairpin condensers are a preferred choice when cleaning requirements are critical.

3. Heated agitator

The heat transfer surface plays an important role in the efficiency of the vacuum drying process and a heated agitator can be an interesting solution when products are sticky or have demanding flow properties, or when specific heat treatment is required. The heating medium in this system is fed and returned to the agitator through the hollow drive shaft of the gearboxes outside the vessel.





4. Inlet-Outlet ISEM™ ball segment valve

Hosokawa Micron has developed the unique ISEM ball segment valve as an in- and outlet valve for mixers and vacuum dryers. This valve is gas, dust and liquid tight, has no flow resistance when opened and is easy to clean and access. The full bore passage, the housing without static pockets and the sealing designs make it the best valve for applications where reliability of the valve sealing is a key issue.

The ISEM valve has proven its reliability under difficult conditions and is a very popular valve for process installations using vacuum or pressure in combination with solvents or toxic materials. The ISEM valve has also been adopted by other machine manufacturers as an addition to their own mixers, dryers and reactors.

Typical applications of the ISEM ball segment valve include:

- Charge and discharge valve for mixers, dryers, sterilisation systems and reactors
- Pre-dosing valves in packing systems
- Barrier valve in process installations
- Flip-flop valves for powder dosing in pressure systems



6. Controls

Our control systems consist of two automation systems:

- Programmable Logic Controller (PLC) to control the vacuum dryer system
- Multi-panel for operation of the vacuum dryer system without data acquisition and logging

Data acquisition and logging are subordinate to GAMP and FDA standards and can be realised using a Distributed Control System (DCS).

5. Filters

Our vacuum filters have been specially designed to operate in conjunction with our Nauta® vacuum dryers. The vacuum filter minimises pressure loss and in most cases, the vacuum filter housing is welded on the domed vessel cover. The filter is heated by means of a pipe coil around the filter housing. Size and specifications depend on product, solvent and the volume of vapours to be handled. Automatic reverse jet cleaning systems are standard and the filter body and cover are jacketed to avoid condensation from the vapours passing through the filter.



Vacuum dryer models and evaporation capacities



Models & specifications

Hosokawa vacuum dryers are available in many sizes. A number of sizes with their typical characteristics are described below. Please note that these values are indicative only. Detailed information on all models is available on request.

Model (water filling)	[l]	5	80	500	1000	5000	12 000	22 000
Height (H)	[mm]	1420	2660	3920	4460	6840	8450	9950
Width (W)	[mm]	600	900	1470	1720	2710	3730	4290
Net volume (powder filling)	[l]	4.3	68	430	840	4500	12 000	22 000
Jacket surface area	[m ²]	0.13	0.69	2.84	4.58	13	25	33
Max. evaporation of water*	[kg/h]	1	5	25	35	100	190	250
Max. evaporation of ethanol*	[kg/h]	3	12.5	60	85	250	400	600

* with jacket surface temperature T=50°C



Key features

Fast drying times

With excellent product transportation along the vessel wall, Hosokawa Micron’s vacuum dryers guarantee a faster and more efficient drying cycle. Moreover, the quick and efficient removal of vapours results in dried solids that are suitable for direct use. All of our specialists can assist you in the selection of the most suitable technologies for your specific application and product requirements.



Multipurpose

Hosokawa Micron’s vacuum dryers are very suitable for drying materials such as powders, granules, pastes and slurries, especially when they are heavy, sticky, brittle and/or heat sensitive. However, they are also suitable for vacuum operation, reaction, heating, cooling and de-aeration.



Systems engineering

Hosokawa Micron strives to meet even the highest of client specifications and provides solutions that comply with all of the relevant international standards (FDA, cGMP, EHEDG). Our systems engineering encompasses automated solutions with our patented CIP (Cleaning-In-Place) skids, SIP (Sterilization-In-Place) skids and customised seal and mechanical seal designs, including sterile versions.



Fast drying times
Slurry
Wet powders
Low maintenance

Reliable
Multipurpose
Granules
CIP/SIP

Paste

Active Freeze Dryer

Freeze drying (lyophilisation) has been used industrially for decades to preserve foodstuffs and organic materials. However, traditional tray-type freeze dryers have proven to be labour-intensive. The Hosokawa Active Freeze Dryer eliminates this drawback and is a big step forward in the field of freeze drying thermo sensitive bulk solids as well as in powder technology in general. Due to the agitated freeze drying process, different product characteristics can be improved without the need of post-processing steps.

Active Freeze Drying offers unique possibilities for turning a variety of materials into a fine loose powder in just one single step. Material consistencies include:

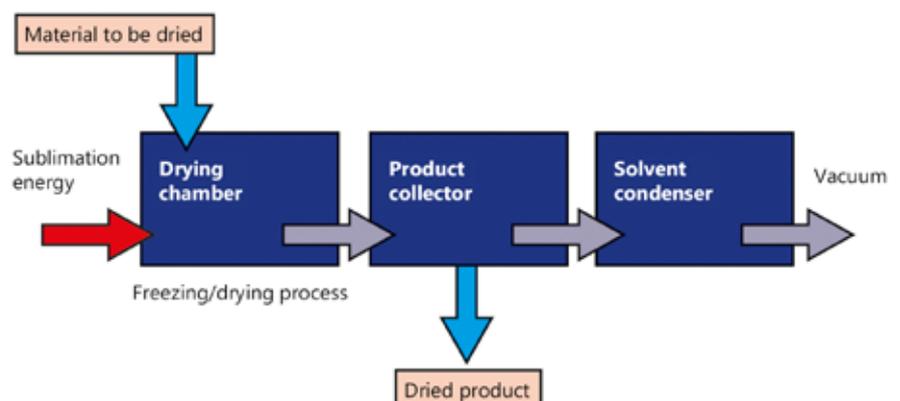
- Solutions
- Dispersions
- Pastes
- Wet solids

Efficiency, minimal handling and product quality are the key benefits of this new, unique technology. Typical applications include pharmaceuticals like antibiotics, proteins, collagens, API's and electrolytes. Numerous successful applications are also found in food and food additive applications like herbal extracts, milk derivatives, enzymes, broth extracts, vegetables, lipids, insects, flavours, fibres, proteins and soups. This new technology has also proven its suitability to the freeze drying of special materials like nanomaterials, polymers, ceramics, pigments, fillers, lime stone, catalysts, glass powder and salts.

Working principle

In an Active Freeze Dryer, the product is first frozen dynamically in a specially-designed chamber. Whether the material to be dried starts off as a liquid, granular solid or paste, the movement inside the drying chamber ensures that it freezes quickly in the form of free-flowing solid granules. Once the product is fully frozen, a deep vacuum is applied and the sublimation starts. Heat applied to the vessel jacket is effectively distributed throughout the product due to the dynamic environment. The initially coarse, frozen granules gradually shrink as the ice structure connecting the frozen material sublimates, yielding a loose powder consisting of fine, dry particles.

As the solvent disappears, the product temperature starts to rise until it equals the jacket temperature. This marks the end of the drying process. Once the vacuum has been released, the chamber is opened and the powdered product can be discharged.





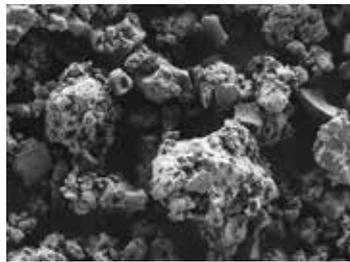
Key features

Efficient and contamination-free

The Active Freeze Drying process is less labour-intensive than the traditional tray freeze drying process. This new process produces lump free, free-flowing powders in one single step. Consequently, the handling is significantly shorter and simpler, and perhaps more importantly: there is hardly any risk for contamination which is ideal for sterile materials.



API in tray dryer



Same API in Active Freeze Dryer

High Quality

Due to this alternative and much faster method of freezing the substrate, the structure of the end product is different and in the majority of cases, will result in an amorphous-like structure with better (re)dispersibility and free-flowing properties. In addition to this, the particle size of the final product is often extremely fine and uniform.

Compact

The Active Freeze Dryer is a compact piece of equipment that requires much less floor space than conventional tray drying installations which usually comprise of horizontal vessels, freezer and tray handling machinery. Hosokawa Micron has converted all of this into a single vertical dryer.

The 1 litre lab size AFD is a plug and play version consisting of:

- Product chamber
- Filter and product collector
- Support frame on wheels
- Heating and cooling unit (inside the frame)
- Vacuum pump (inside the frame)
- Control system (inside the frame)
- Interface (on the frame)



Faster **Simple**
High product quality
Free-flowing powder
Efficient **Less labour-intensive**

Models & specifications

The Active Freeze Dryer is available in several models. A number of models with their typical characteristics are described below. Please note that these values are indicative only. Detailed information is available on request.

Model	[l]	1	5	20	60	100	500	800	1000	1500
Max. net product volume (liquid)	[l]	0.5	2.5	10	30	50	250	400	500	750
Jacket surface area	[m ²]	0.06	0.13	0.33	0.69	0.98	2.84	3.93	4.58	5.99
Max. sublimation capacity at p = 2 mbar	[kg/h]	0.1	0.3	0.8	1.7	2.2	7.2	9.9	11.4	13.7

Disc dryer

The disc dryer uses hot air or gas as a drying medium in combination with a heating jacket and heating rotor. The rotor consists of special, heated discs within a cylindrical jacketed housing. It is a low-speed, horizontal, indirect dryer, suitable for heating and cooling various types of product like filter cakes, powders, viscous materials and granules.

The disc dryer can be used for batch or continuous operation, can operate under pressure or vacuum and can process:

- Wet powdery materials
- Wet cakes
- Materials requiring very long residence times
- Sticky materials with back-mixing

It is a compact machine that combines high heat transfer rates ranging from 85 to 300 W/m²K with high surface/volume ratios. Residence times range from minutes to several hours, making the disc dryer more versatile than almost any other indirect heat exchanger available today.

Working principle

The rotor is designed with vertically-mounted, double-walled hollow discs. Heating media flows through the rotor, the discs and the jacketed vessel surrounding the rotor with the discs providing 85% of the total heating surface.

The rotor speed varies from 0.1 up to 0.5 m/s and is not dependent on the residence time, enabling optimum mixing and optimum heat transfer. The residence time can be adjusted from several minutes up to several hours.

The wet product is fed into the inlet of the disc dryer and the rotating discs gently convey the product towards the outlet. Stationary ploughs or breaker bars are located between the discs in order to achieve better mixing and prevent material build-up on the heat transfer surface. Combined heating of the rotor and the jacket results in high heat-efficiency transfer and the dry product is discharged at the outlet port.

The twin disc dryer provides 20-30% more heat transfer surface in the same amount of floor space as the single rotor disc dryer. With two intermeshing rotors, this dryer can handle light fluffy materials, fibrous masses and non-free flowing products.





Key features

Compact

The disc dryer requires less space than comparable equipment due to the large heat transfer area on the rotor. A single disc dryer can therefore replace a large number of batch units which also reduces total floor space as well as labour requirements and energy costs.

Energy efficient

The disc dryer can combine indirect and direct drying for maximum drying efficiency. The disc dryer has a thermal efficiency of 1.1 to 1.4 kg steam per kg evaporated water, compared to efficiencies of 1.8 to 2.0 for batch cookers and steam tube dryers. The difference can result in fuel savings of 20 to 40%.

Versatile

The disc dryer can process wet cakes and slurries, even for materials requiring very long residence times. Scrapers facilitate the processing of sticky materials in combination with thorough mixing and no product build-up. In extremely difficult cases, back-mixing of the product with feed is used to provide a free-flowing bed and clean heat transfer surfaces.



High capacity Energy efficient
Adjustable residence time
Versatile Compact design

Models & specifications

The disc dryer is available in many sizes. A few sizes with their typical characteristics are described below. Please note that these values are indicative only. Detailed information is available on request.

Model (Ø - L)	[m]	0.63 - 2.00	1.25 - 5.00	1.60 - 7.00	2.50 - 10.00
Working volume	[m ³]	0.6	5.2	12.3	37
Heat transfer area	[m ²]	11.2	86	189	572
Electric power installed rotor	[kW]	4	22	51	110
Water evaporation capacity at ΔT=200°C, U=150 W/m ² K	[kg/h]	554	4256	9353	28 307

Paddle dryer

The paddle dryer is a highly versatile indirect and direct heat exchanger equipped with a jacketed cylinder and a high-speed paddle rotor that creates a highly agitated, dense, thin layer of material against the jacketed vessel wall. It is designed for continuous drying, heating, cooling, reacting and crystallising applications.

The paddle dryer is only for continuous operation and can process:

- Free-flowing solids
- Wet filter cakes
- Slurries
- Gels

High paddle tip speed (10-20 m/s) creates turbulence in a thin material layer, breaks agglomerates and ensures heat transfer coefficients of 100-150 W/m²K depending on moisture content of the feed, and the other product properties. Residence times in the paddle dryer can be varied from seconds to approximately 20 minutes by adjusting paddle pitch or by changing the rotor speed.

Working principle

Essentially, the paddle dryer consists of a horizontal mechanical agitator rotating within a cylindrical housing. The housing is equipped with a heat transfer jacket which may be constructed for steam or liquid heat transfer media.

Jacket operating pressures of up to 10 bar (g) (150 psig) are typical and the housing can be designed to operate above or below atmospheric pressure.

A large number of narrow flat, adjustable-pitch paddles are attached to the agitator, which sweep close to the inner surface of the cylindrical housing. The arrangement of the paddle and the agitator tip speed combine to move material in a thin, annular spiral from inlet to discharge along the housing's inner shell. This results in maximum heat transfer efficiency.

The paddle dryer's adjustable paddles can convey materials with poor flow, and can be adapted to variations in flow during drying.





Key features

Thin layer processing

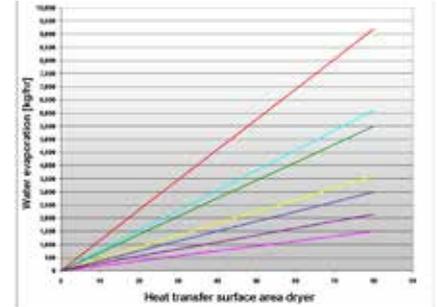
Residence time in the paddle dryer can be varied from seconds to approximately 20 minutes by adjusting paddle pitch or rotor speed. Paddle arrangement and agitator tip speed (10-20 m/s) combine to move material in a thin, annular spiral from inlet to discharge along the housing's inner shell, resulting in maximum heat transfer efficiency.

High heat transfer coefficients

Created turbulence increases heat and mass transfer and results in high heat transfer coefficients in the order of 100-150 W/m²K depending on moisture content of the feed and the other product properties.

Three operating modes

The paddle dryer operates in three basic heat-source modes. Heat can be transferred indirectly through the cylindrical housing wall by conduction and directly by convection using gas flow as the heat source. The third method is a combination of direct and indirect heat.



High capacity

Energy efficient

Less labor-intensive

High heat transfer

Models & specifications

The continuous paddle dryer is available in many sizes. A few sizes with their typical characteristics are described below. Please note that these values are indicative only. Detailed information is available on request.

Model (Ø - L)	[m]	0.2 - 1.25	1 - 7.10	2.24 - 15.00
Heat transfer area	[m ²]	0.7	19	107
Cross section area	[m ²]	0.03	0.52	2.30
Max. power installed	[kW]	4	75	200
Max. rpm		1520	310	100

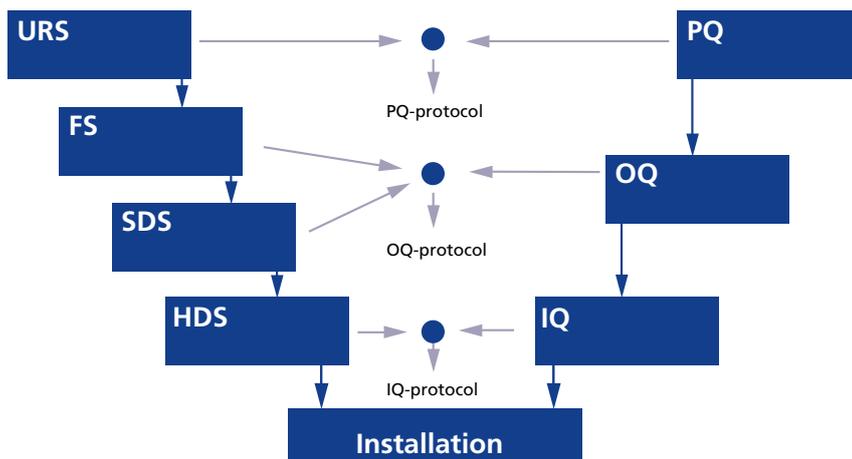
Process Automation

Process automation is an inextricable part of every drying system, which is why Hosokawa Micron B.V. has an experienced team of process and electrical engineers at hand to help you identify the right degree of automation for your processes. Our engineers are experts in translating process technology know-how into essential hardware and essential software for optimum custom-made control solutions.

Qualification

Prior to the planning stage, our engineers will investigate the special demands of your production sequence, the restrictions created by the supply network and the environmental conditions in your production area (e.g. a potentially explosive atmosphere, for example gas and/or dust). They will then systematically convert their findings into a viable concept.

The diagram below illustrates the process that our engineers adopt for system qualification.



Hardware

Selecting the correct hardware is essential for an efficient and reliable production sequence. Our engineers combine safety, switching and operating elements that best suit the production process and the environmental conditions of your production site and incorporate these into your custom-made control cabinet. It is inspected and tested before leaving Hosokawa Micron's manufacturing facilities in terms of functionality and quality and in accordance to international IEC and EN standards.





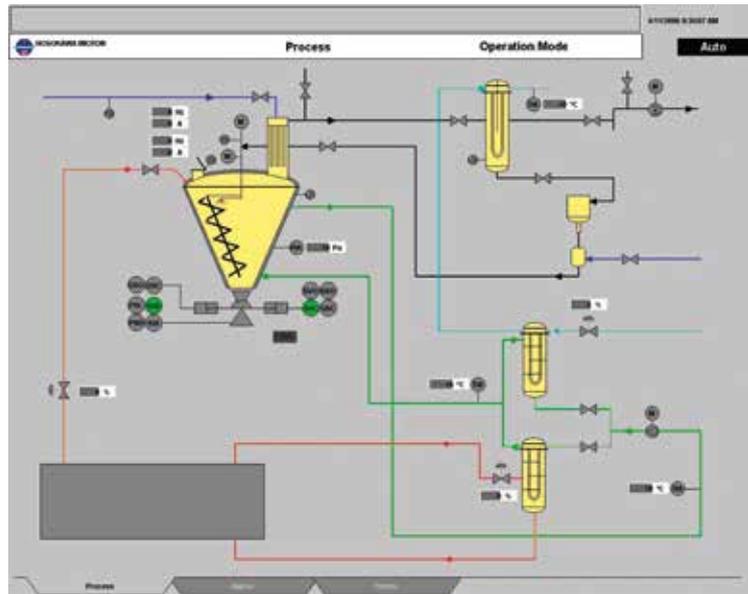
Software

We then create a tailor-made software program that matches your process precisely, but is nevertheless flexible enough to allow for quick and easy adaptations or process upgrades. The process control software is universally structured and documented. We use tried and tested program modules for maximum reliability. These can be retrieved from libraries, permitting efficient program generation for your process control unit.

Before the process control unit is delivered, we carefully test the function of the software. This means that you can concentrate fully on process optimisation during the implementation, without having to worry about any unwanted delays.

Process visualisation

We have two different visualisation systems available depending on your requirements. For simple processes, we provide a Windows-based operating and monitoring system. For more complicated processes, we work with state-of-the-art process visualisation software.



User-friendly & reliable

Hosokawa Micron's systems, hardware and software are all tried and tested. Our control solutions have been implemented throughout a wide variety of industries. They are user-friendly, error-free and reliable, because we have reinvested the practical experience gained from these implementations into the optimisation and improvement of our process technologies and our automation controls.

Practical operation
Modular
Tailormade **User friendly**
Reliable
Automation engineering
Process visualisation



Food & Beverages

Hosokawa Micron's drying systems offer quality and functionality, are easy to clean and energy efficient. In the food sector, our drying equipment is used for the freeze drying of food and feed products as well as related processes such as alkalisation, sterilisation and pasteurisation. Additionally we have unique expertise regarding freeze drying of food and feed products.

Food safety

Hosokawa Micron is an active participant in the European Hygienic Engineering & Design Group (EHEDG). This is a consortium of equipment manufacturers, food industries, research institutes and public health authorities whose goal it is to increase food safety by improving hygienic engineering and design in all aspects of food production. The long term benefit of this is not only improved product safety, but also increased durability of equipment, reduced corrective maintenance and consequently, lower operating costs. Likewise, Hosokawa Micron is able to engineer and manufacture in accordance with 3-A sanitary standards.



Quality & functionality

By combining premium quality with optimal functionality, Hosokawa Micron's equipment can comply with the highest of international safety standards. All of our machines and systems meet the requirements of highly-automated food manufacturing including its most innovative processes.

Energy efficiency

Similarly, our wealth of experience and know-how in designing energy-efficient solutions means that Hosokawa Micron's dryers are some of the most environmentally-friendly on the market.

Fish feed **Alginate**
Meat proteins **Herbs & Spices**
Cocoa Flavours **Fruits & Vegetables**
Yeast **Natural Colorant** **Okara**
Sweeteners **Chocolate**
Fish meal

Applications





Vaporising liquids instead of Money

Applications and processes

- Continuous flash drying of alginates & CMC
- Continuous flash drying of fish & fish feed
- Sterilisation of herbs & spices
- Freeze drying of food ingredients like garlic, algae, fruits & vegetables, etc.
- Freeze drying of plankton
- Freeze drying of milk products
- Freeze drying of colostrum and breast milk
- Alkalisiation & drying of cocoa nibs
- Heat treatment of starch flour
- Pasteurisation of baby food powder
- Vacuum drying of nutrients

Services

- Global organisation and support
- Process development
- Process testing and validation in well-equipped test centre
- Toll processing for product benchmark testing before market introduction
- Manufacturing support for scaling up production levels
- Hygienic systems possible in accordance with EHEDG guidelines and 3-A sanitary standards



Fruits & vegetables



Fish



Herbs & spices



Cocoa



Applications

Pharmaceuticals

Drying is an important part in the pharmaceutical production chain. It requires extra-special care due to the sensitivity of the products, as well as strict organisation and equipment that complies with the most stringent of industry standards. Temperature, hazardous materials and sterility are just a few of the application's most vital considerations.

Developing new technologies

It is Hosokawa's ambition to support its customers throughout the product life cycle with technology that has been specially developed for some of the industry's most demanding applications. This is why we continue to invest in the development of new technologies, additional expertise and industry-specific services.

Safety regulations

In the pharmaceutical industry, safety has the highest priority. To meet the stringent international FDA, cGMP and GAMP standards, Hosokawa Micron has developed a range of technically sophisticated systems with top quality surface finishes, hygienic designs and which offer optimal cleaning.

Scaling up production

The pharmaceutical industry demands a wider range of equipment sizes than other industries. Each phase of the product development process, from feasibility studies, the development phase and on to full scale production, sets different requirements. As a supplier, it is up to us to cater to these varying demands, which is why we offer customers the flexibility of our three product ranges for scaling up production:

- Lab scale batch sizes: 0.3 - 5 litres
- Development scale batch sizes: 1 - 120 litres
- Production scale batch sizes: 25 - 10 000 litres



Antibiotics
Fine Pharmaceuticals
Blood pressure regulation
Sterile intravenous medicines
Injectables



Special care for your products by Hosokawa

Applications and processes

- 0.3 - 1 litre Active Freeze Drying system
- Multipurpose 1 - 120 litre vacuum drying systems with multiple agitating mechanisms
- CIP vacuum drying system for orally administered active pharmaceutical ingredients (APIs)
- SIP conical paddle drying system for injectable antibiotics
- Thermal post-vacuum drying after initial spray drying phase of API containing solvents
- Vacuum and overpressure tight ball segment valve in CIP and SIP execution
- Sampling devices for conical batch processes in CIP and SIP execution

Services

- Global organisation and support
- Process development
- Process testing in well-equipped test centre
- Machine rental
- Scale up support from lab to industrial production
- Dedicated project management
- Advice on validation documentation and protocols, DQ, IQ, OQ and assistance for PQ
- Systems design according to latest directives like cGMP, GAMP, FDA, ISPE, EHEDG, etc.
- After sales support from our technical service department



Phase 1
Drug
discovery &
development



Phase 2
Lab testing



Phase 3
Equipment
development



Phase 4
Production of
equipment



Chemicals

The field of activity of the chemicals division is just as wide and diverse as the overwhelming number of substances for which Hosokawa Micron offers drying solutions. The drying process in the chemical industry is often critical, demanding the highest of industry standards. Three important aspects worthy of special attention are flexibility, energy efficiency and safety.

Flexibility

As product life cycles shorten, production facilities in the chemical industry need to be equipped for making easy adjustments for the manufacture of alternative products. Hosokawa Micron's dryers and systems are designed for this very purpose: for handling a wide range of different materials with varying product properties.

Energy efficiency

When it comes to energy efficiency, we fabricate our drying systems using the latest technologies to precise specifications. This way, we can increase energy efficiency, improve process optimisation and reduce operational costs. In fact, Hosokawa Micron's dryers are some of the most environmentally-friendly on the market.

Safety

Hazardous materials are synonymous with the chemical industry and drying them requires specialist treatment. More importantly, these kinds of materials demand stringent safety requirements. Needless to say, Hosokawa Micron always applies the highest safety standards to all of its products and process systems.

Catalysts Zeolite **PE resin**
Metal stearates
Acrylates PVC
Copper hydroxide
Dicalcium phosphate **Pigments**
Titanium dioxide
CMC Magnesium hydroxide

Applications





Hosokawa feel the chemistry



Applications and processes

- Batch or continuous indirect drying of polymers
- Continuous direct drying of pigments and dye stuff
- Continuous direct or indirect drying of aluminium oxide
- Continuous direct or indirect drying of high strength fibres
- Continuous indirect drying of aluminium trihydrate
- Continuous indirect drying of PET
- Continuous indirect drying of super absorbent polymers (SAP)
- Continuous indirect drying of titanium dioxide
- Continuous direct or indirect drying of paper pulp
- Continuous flash drying of agrochemicals
- Continuous flash drying of flame retardants
- Continuous flash drying of pigments
- Freeze drying of nanomaterial
- Vacuum drying of catalysts
- Vacuum drying of chemically produced toner (CPT)
- Vacuum drying of crop protecting agents
- Vacuum drying of metal salts
- Vacuum drying of nuclear waste

Services

- Global organisation and support
- Testing and validation in well-equipped test centre
- Scale up support from lab to industrial scale
- Dedicated project management
- Use of our test facilities: challenge us with your drying problem, send us a sample of your product for us to test and we will provide you with the optimal drying solution



Catalysts



Chemically
Produced
Toner (CPT)



Polymers



Agrochemicals



Minerals & Metals

Hosokawa Micron provides the minerals and metals industry with a wide range of reliable and robust drying equipment, from single unit to turn key system. We offer proven technologies and have the know-how and experience for a successful operational concept for your product. Typical requirements for minerals and metals include high productivity, reliability and low operational costs.

Productivity

In the mineral industry drying systems usually combine rotary dryers, flash dryers or fluid-bed dryers in combination with a separate milling system. This involves several units and multiple transfers between process steps. Hosokawa Micron offers a single system capable of drying, grinding and classifying minerals and metals in one compact operation, with close control of the product particle size and final moisture content. We call this system the Drymeister-H.

Operational costs

The Drymeister-H combines a high temperature inlet with a relatively low temperature outlet. Optimal dispersion ensures that the product takes over the heat of the drying gas quickly, leading to smaller sized drying systems and less energy consumption per kilogram. An interesting advantage here is the resulting reduction in operational costs. For small quantities of metals and minerals, we recommend the vacuum batch dryer.

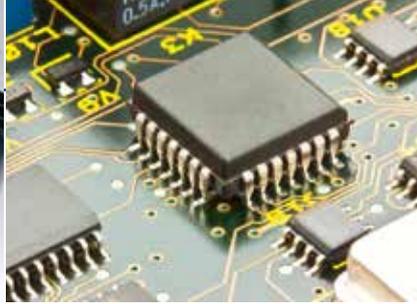
Reliability

Hosokawa Microns drying systems have a global reputation of high reliability. We offer state-of-the-art technology that has proven to be highly efficient and extremely reliable. Every system is engineered for high performance with maximal durability and minimal downtime. To ensure this, we always apply adequate measures for maximum safety, for your product, the operator and the environment.

Gypsum **Magnesium oxide**
Calcium carbonate **Ceramics**
Feldspar **Talc** Aluminum oxide
Zinc oxide **Bentonite** **Quartz**
Aluminum silicates **Lithium powder**
Kaolin **Fillers** Zircon sand
Graphite **Precious metals**
Rare earths

Applications





Hosokawa, rock solid solutions

Applications and processes

- High temperature indirect drying of graphite
- Continuous flash drying of bentonite and kaolin
- Continuous flash drying of gypsum
- Continuous flash drying of silicates
- Continuous flash drying of metal carbides
- Vacuum drying of metal powders
- Continuous direct or indirect drying of barite

Services

- Global organisation and support
- Process development
- Process simulation to prove product quality and process functionality
- Contract manufacturing
- Use of test station flash dryer (DMR-H) with an inlet temperature up to 650 °C
- Use of test station batch high temperature vacuum dryer (>300 °C)



**Metal
powders**



**Zeolite
(cat litter)**



Precious metals



**Calcium
carbonate**



Testing & Tolling

Hosokawa Micron B.V. has its own testing and development centre in Doetinchem, the Netherlands. It offers unique possibilities for testing your product to determine the most efficient process, system or plant prior to final design. We can provide laboratory as well as production-sized trials.

Whether you wish to test a single machine or a complete powder processing system, the same skilled and experienced staff are here to help ensure that your requirements are met, and that you are entirely satisfied with the results.

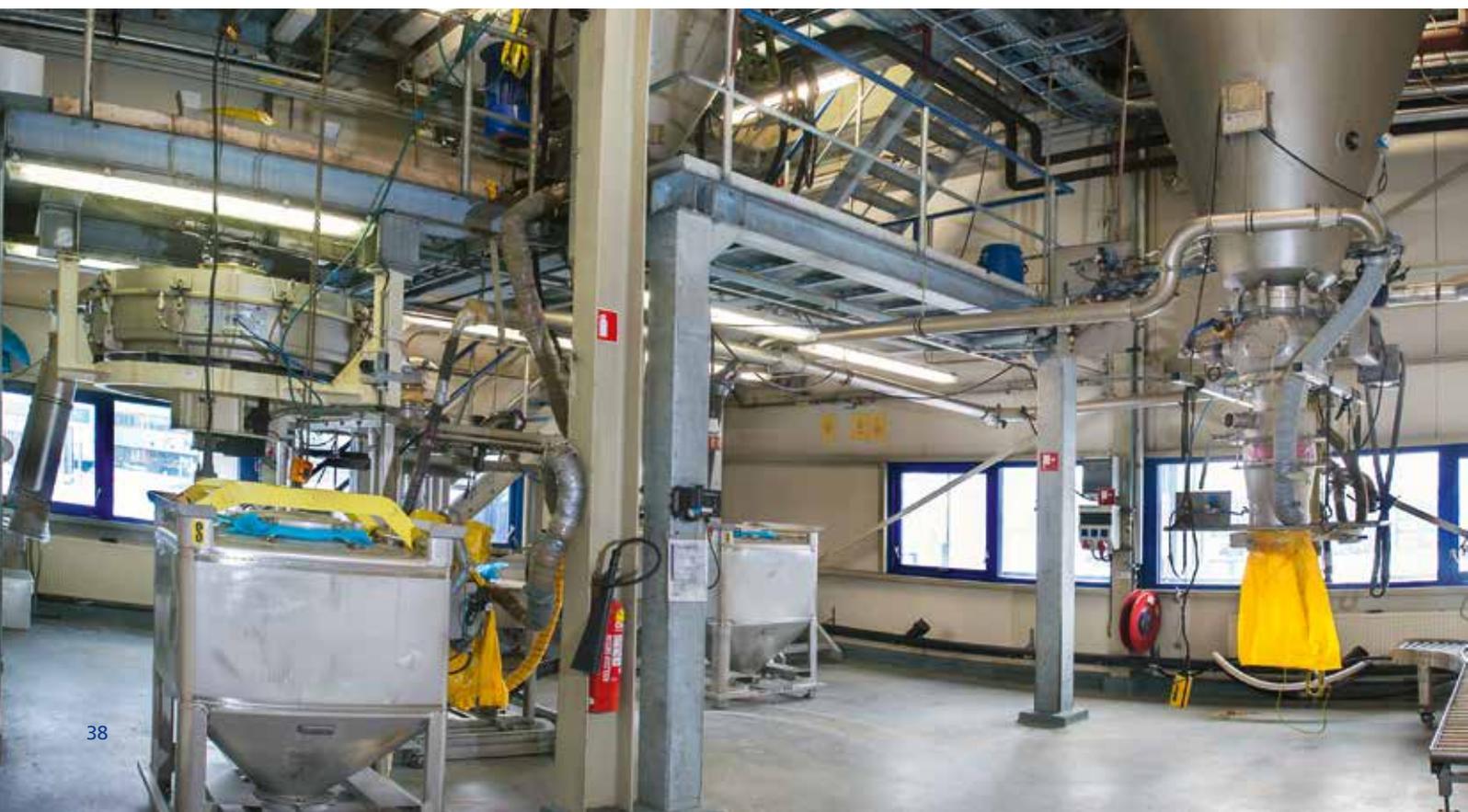
We have test equipment at your disposal for:

- Batch mixing from 1 up to 6000 l
- Continuous mixing from 2.5 up to 1000 kg/h
- Batch vacuum drying from 5 up to 6000 l
- Batch freeze drying of 1.5, 5 and 60 l
- Continuous drying from 1 up to 250 kg/h (evaporation)
- Batch agglomeration from 5 up to 500 l
- Continuous agglomeration from 50 up to 500 kg/h

Is testing necessary?

If we could summarise the behaviour of powders in a set of rules and guidelines, in other words, if results could be predicted, then testing would be unnecessary. Of course the reality is somewhat different. Testing isn't only necessary; it is the foundation of any successful product or process. At Hosokawa Micron B.V., we enjoy helping our customers test their latest ideas and requirements and with our modern testing facilities, we can help you put theory into practice.

Testing & Tolling





Rental equipment

Our testing centre is full-equipped with all of our latest equipment for operational trials but we also offer a range of rental equipment so that you can carry out operational trials at your own facilities too. This means that you can fine tune process parameters and monitor production flows prior to finalising equipment choices and process designs. To help things go smoothly, our experienced process engineers will work closely with your engineering team to advise and develop the best solution for your processing requirements.



Toll processing & Contract manufacturing

Besides testing, we also offer a wide range of toll processing & contract manufacturing services ranging from single to multiple processes, for batch and continuous drying.

Your advantages

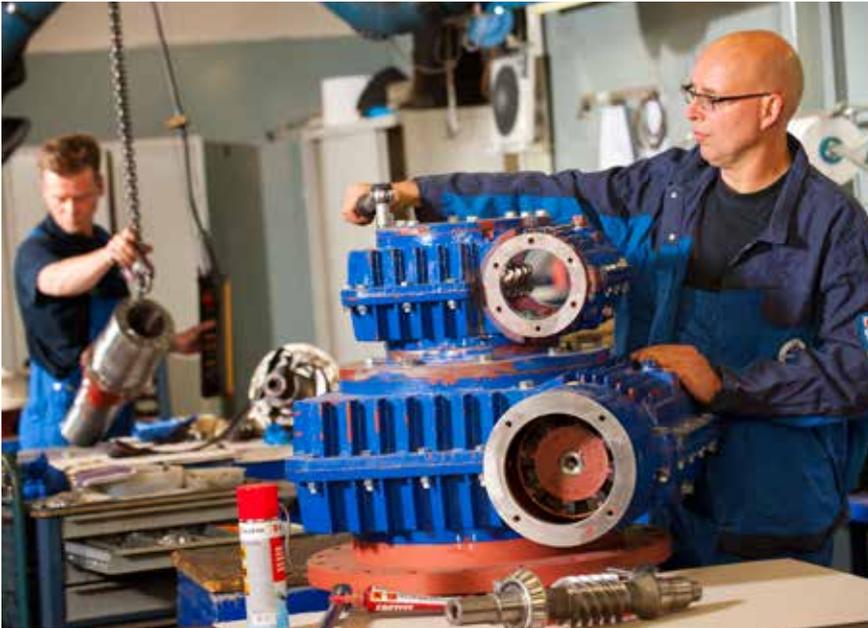
- Clearly defined costs
- No investment in equipment and buildings
- Efficient production of small quantities
- Test your process on a lab and production scale
- Define the specifications of your machine
- Use toll processing as part of your development process
- Produce materials for marketing activities, prior to investing in new production capacity
- Fill the gap between design and start up of your new equipment or plant
- Launch new products using toll processing, until your sales have reached a solid and profitable base

Testing
Contract manufacturing
Toll processing
Rental equipment
Laboratory- and production scale trials



Service & Support

Downtime is unacceptable, which is why customers demand security and peace of mind for their processes and service and support for their machinery. Hosokawa Micron B.V. can pride itself on a highly-competent engineering department and a responsive and smoothly operating service department.



Repair & maintenance

Our Technical Services Team carries out repair and maintenance services onsite or in our own fully-equipped workshop in Doetinchem, the Netherlands, 24-hours a day, 7 days a week. This team comprises specialists in mechanical engineering, maintenance, instrumentation and controls as well as process engineering.

Protect your investment

Create added security for your capital investment with one of our regular maintenance contracts. Our sales engineers will be more than happy to discuss a bespoke agreement that meets your specific maintenance needs, either for single machines or entire process lines.

Spare Parts Service

Minimise the hassle of sourcing spare parts with our Spare Parts Service. We have a team of engineers on standby that can deliver the spare parts and install them for you on site. And if that isn't efficient enough, we will happily discuss the options for your own in-house Hosokawa Micron B.V. inventory: spare parts to hand, 24/7.

Predictable **Reliable**
24 hrs service & support
 Avoid down-time **Upgrade**
 Repair Value for money
Improve Replace



+31 314 373 505



Preventative maintenance

Preventative maintenance means knowing that your production processes are in good working order and increasing the lifetime of your plant. Hosokawa Micron B.V. has a dedicated team of experienced maintenance engineers specialised in just this: providing on-site advice, engineering and training to help you optimise your processes. Our experienced engineers are focussed on identifying potential mechanical, safety and process line problems before they cause unnecessary downtime.

On site services

- Preventative maintenance
- Inspection and troubleshooting
- Repair & service
- Process support and optimisation
- Modifications and upgrading to latest technology
- Internal transport, relocation and construction
- Operator training either onsite or in Doetinchem, the Netherlands
- Commissioning
- Certification and validation
- Reconditioning of used machines
- Swap drives

Replacing old machinery with new

A retrofit, upgrade or refurbishment can be easier and more economical than specifying and buying new. Hosokawa Micron B.V. offers exactly that: a combination of our high-quality products and spare parts with expert design and engineering as well as experienced manpower. Our goal is to make sure you are left with equipment that performs at the same level as the brand-new equivalent.

Retrofitting

We will send in our expert engineers for an initial assessment, fix mechanical failures and replace broken parts. In short, we will give your machines a new lease of life. Any new parts come with a 12-month guarantee but may well last another 25-30 years! That's what we call value for money.

Upgrading

Our engineers can also help you improve production, increase capacity and upgrade your existing processes to the latest industry standards. We can minimise mechanical failures, convert to food-grade specifications and CIP cleaning, all without necessarily having to replace the entire system.

Refurbishment

Refurbishment is more than a retrofit or upgrade. It's the whole package. From start to finish, we will work with you to improve your processes: come up with a plan, improve, repair, replace and upgrade whilst considering the application, the market sector, industry standards and of course your wishes and requirements.



HOSOKAWA

MICRON

Hosokawa is the world's largest provider of processing systems for the field of powder and particle processing. Renowned brand names such as Alpine, Micron, Nauta, Schugi, Stott, Vitalair and Vrieco are all included in the Group's range.

Regardless of the size, i.e. production-scale systems, pilot systems or laboratory equipment, Hosokawa's products and technologies are used in numerous process stages, for example during mixing, drying, agglomeration, containment, filling, metering, size reduction and classification.



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HOSOKAWA MICRON B.V.

Hosokawa Micron B.V. is a member of the Hosokawa Micron Group, responding to global needs through emphasis on materials science and engineering. The Group is an international provider of equipment and technology for powder and particle processing, plastics processing and confectionery products. The Group maintains facilities for research, engineering, manufacturing and service in each of the world's major industrial markets.

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