

# Liquid Clarification Systems



Turnkey skid packages for filtration, adsorption, thickening and polishing

**BHS**  
**SONTHOFEN**

# Over 50 years experience in solid-liquid separation

## The company

Our company history stretches back over 400 years in the German mining and industrial sector. Today we are a mid-sized independent group of companies with over 300 employees and are the innovative leader in machine and plant engineering for mechanical process technology, especially in mixing, crushing, recycling and filtration. We provide our world-wide customers with reliable, well-engineered, state-of-the-art process solutions.

## Specialist in solid-liquid separation

BHS specializes in thin-cake filtration (3-180 mm), cake washing and drying technologies. BHS serves the three major market segments as follows:

- Chemical (fine, specialty, agricultural and others)
- Pharmaceutical (bulk and final products)
- Energy & Environmental (refinery, power plants, bio-energy and wastewater)

## Specialized applications & centers of excellence

For specialized applications, BHS is organized globally with centers of excellence. These centers include, for example, aromatic acids, cellulose derivatives, pharmaceuticals, dewatering of gypsum, refinery and bio-energy applications.

## Patented filtration technology

Filtration systems for separating solids and liquids have been in production for over 50 years. Our product range consists of several different filter types, providing the optimum process solution. The BHS worldwide patented technologies include the rotary pressure filter (RPF), indexing belt filter (BF) for continuous vacuum filtration, autopress (AP) for gas-tight and fully automatic batch operation, candle filter (CF) and pressure plate filter (PF). Furthermore we provide rubber belt filters (BFR), lab filters, pilot filters and turnkey skid packages. These technologies are installed for pressure or vacuum filtration, for batch or continuous operations from high solids slurries (up to 60% solids) to clarification applications with solids to less than 1% and trace amounts.

## Process lab testing & on-site pilot testing

For the filtration technology we perform tests with our pocket leaf filters in our worldwide laboratories. These tests can be performed quickly and easily together with our experts at your location or in our laboratory. Through these tests, you can gain basic data about the filterability of a suspension and the general process information for a production filter. For more advanced tests, we have rental pilot and lab filters. The BHS process engineers assist with installation, testing and training for these pilot tests.



Tests with customer specific suspensions in our laboratory in Sonthofen, Germany.

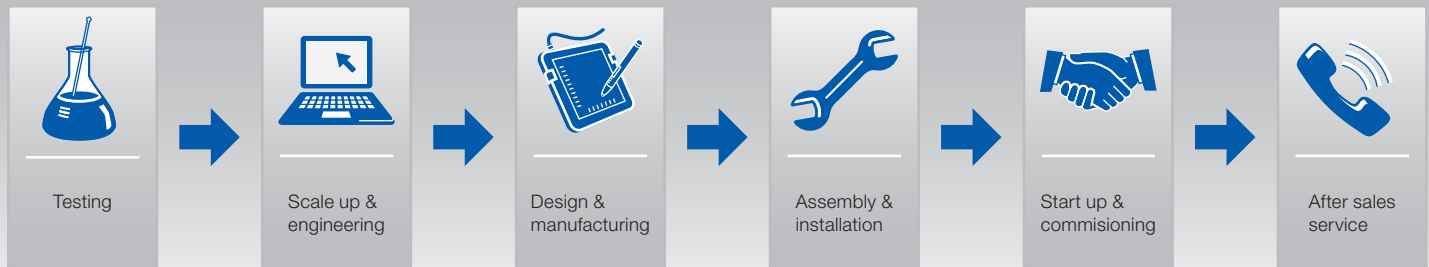


BHS provides dedicated engineering and design.



Installation of a BHS candle filter system at site.

## Your benefits from BHS:



### Testing & process development

BHS provides test services for filtration and process development. Tests can be carried out in the BHS laboratories in Germany and USA, or with the BHS pocket leaf filter (PLF) at the customer's site. Pilot test systems from 0.1 to 1.0 m<sup>2</sup> are available.



### Scale-up & engineering

For new applications BHS conducts scale-up from lab or pilot tests and develops tailor-made solutions for the individual case. Basic and detailed engineering is done by BHS for all process systems for turn-key packages.



### Design & manufacturing

All design work is done in 3D CAD, including piping isometrics, steel structures, PLC controls, etc. BHS filter systems are engineered in compliance to most common codes and standards, including PED, ASME, NACE, API and more. The BHS design concept of modularization offers advantages for fast and safe installation at site.



### Assembly & installation

The BHS filter systems are completely skid mounted packages, assembled by BHS with complete factory-acceptance testing prior to shipment. With the module-design-concept, installation at site is easy, safe and fast resulting in cost, time and manpower savings.



### Start-up & commissioning

Mechanical and process start-up assistance and supervision, water batching and process commissioning is provided by BHS.



### After sales service

BHS specialists are available for immediate service in the field at any time. Our engineers provide for process optimization and consulting. Spare parts and service including annual inspections are provided by BHS worldwide.



# Creating industry & process solutions



## Amine sweetening

BHS candle filters remove coker fines, cat cracker fines and catalyst fines to 0.5 micron filtration from the recirculating amine stream. The filter cake can be washed to remove residual amines as well as dried for non-hazardous disposal. Carbon adsorption systems can also be incorporated.

- Refineries for fluid coker & FCC units
- Cogeneration plants
- Coal-fired power plants for CO<sub>2</sub> capture
- Gas plants



## Water scrubbing & grey water

BHS candle filters are installed downstream of clarifiers for removal of the fine overflow solids to 0.5 micron filtration. The clean water to less than 5 NTUs can be discharged meeting environmental regulations. For coal gasification and other grey water applications, coal fines and catalyst fines are also removed. The solids can be dried for disposal or concentrated for reuse back to the gasifier or in the process.

- Refineries
- Coal gasification

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## Glycol regeneration

BHS candle filters or combined duplex-filters – BHS candle filters for prethickening followed by BHS pressure plate filters for solids washing and drying – remove fines from glycol and other solvents streams. These can be MEG, DEG, TEG, DEPG, aromatics and other solvents and are used in gas dehydrogenation systems, gas pipeline preservation units, aromatics extractions and BTX productions in closed loops. Solid contamination as well as monovalent and divalent salts precipitation need to be removed to enable stable process operation in the reclamation system. BHS candle filters allows purification of the solvents to less than 1 ppm of solids.

- Dehydration at gas plants
- LNG production
- Extraction for aromatics and BTX production



## Challenging clarification applications

BHS candle and pressure plate filters are installed in many critical applications for removing fine solids from liquid slurries. Typical applications are listed below.

- Brine filtration for chlor-alkali
- Coal liquefaction for synthetic oils
- Biodiesel & biochemical



# Applications for liquid clarification systems



Duplex candle filter system in the fabrication shop consists of two candle filters, piping, wiring and complete PLC system with communication back to the refinery DCS.

## Amine sweetening at a refinery

### Description of the application

In this application, the amine sweetening unit is installed to handle a combined stream from the coker and FCC units. The candle filter is designed for 11.35 m<sup>3</sup>/h (50 gpm) and is to remove 95% of all particles greater than 0.5 microns. The mass of solids to be filtered will be 1.36 kg/h (3 lb/hr) from 12 m<sup>3</sup>/h (26,351 lb/hr) of fluid.

### Testing for filtration rate and sizing

The flowrate of amine fluid through the BHS test filter at a feed pressure of 2 bar (30 psig) and a differential pressure of approximately 1 bar (15 psig), is 1.9 m<sup>3</sup>/m<sup>2</sup> h (8.35 gpm/m<sup>2</sup>). The filter media is a proprietary membrane media that does not require the use of precoat to retain particles 0.5 microns and larger. The area required for an 11.35 m<sup>3</sup>/h (50 gpm) flow rate of fluid is 6 m<sup>2</sup>. The design, including a safety factor, is two filter units, each with 10 m<sup>2</sup> of filter area. The operation is that one unit is in operation while the second unit is in the cake drying and discharge mode.



Duplex BHS candle filter system in a refinery with precoat tank and pumps, piping, wiring and complete PLC controls system which communication back to the refinery DCS. All filters, tanks and piping are heat traced and insulated.

## Water scrubbing downstream of a clarifier

### Description of the application

In this application, the water scrubber and clarifier at a refinery are installed to handle the stream from the FCC unit. The candle filter is designed for  $83.57 \text{ m}^3/\text{h}$  (368 gpm) and is to remove particles greater than 0.5 microns to filtrate clarity of 5 ppm.

### Testing for filtration rate and sizing

The flux rate of clarifier water overflow slurry through the BHS test filter at a feed pressure of 5 bar (75 psig) and a differential pressure of approximately 2.3 bar (35 psig) is  $0.8 \text{ m}^3/\text{m}^2 \text{ h}$  (3.6 gpm/m<sup>2</sup>). The filter media is a polypropylene filter media with the use of precoat to retain particles to meet the 5 ppm requirement. The design, including a safety factor, is two filter units, each with 100 m<sup>2</sup> of filter area. The operation is that one unit is in operation while the second unit is in the cake drying and discharge mode. Precoating of the standby unit occurs when the operating unit begins to approach its design differential pressure.





This triplex candle filter system during fabrication are manifolded for concentrated slurry discharge. For this application the system consists of three concentrating candle filters, including piping, wiring to junction boxes. BHS has designed the control system and it is operating by communication with the plant DCS.

## Grey water at a coal gasification plant

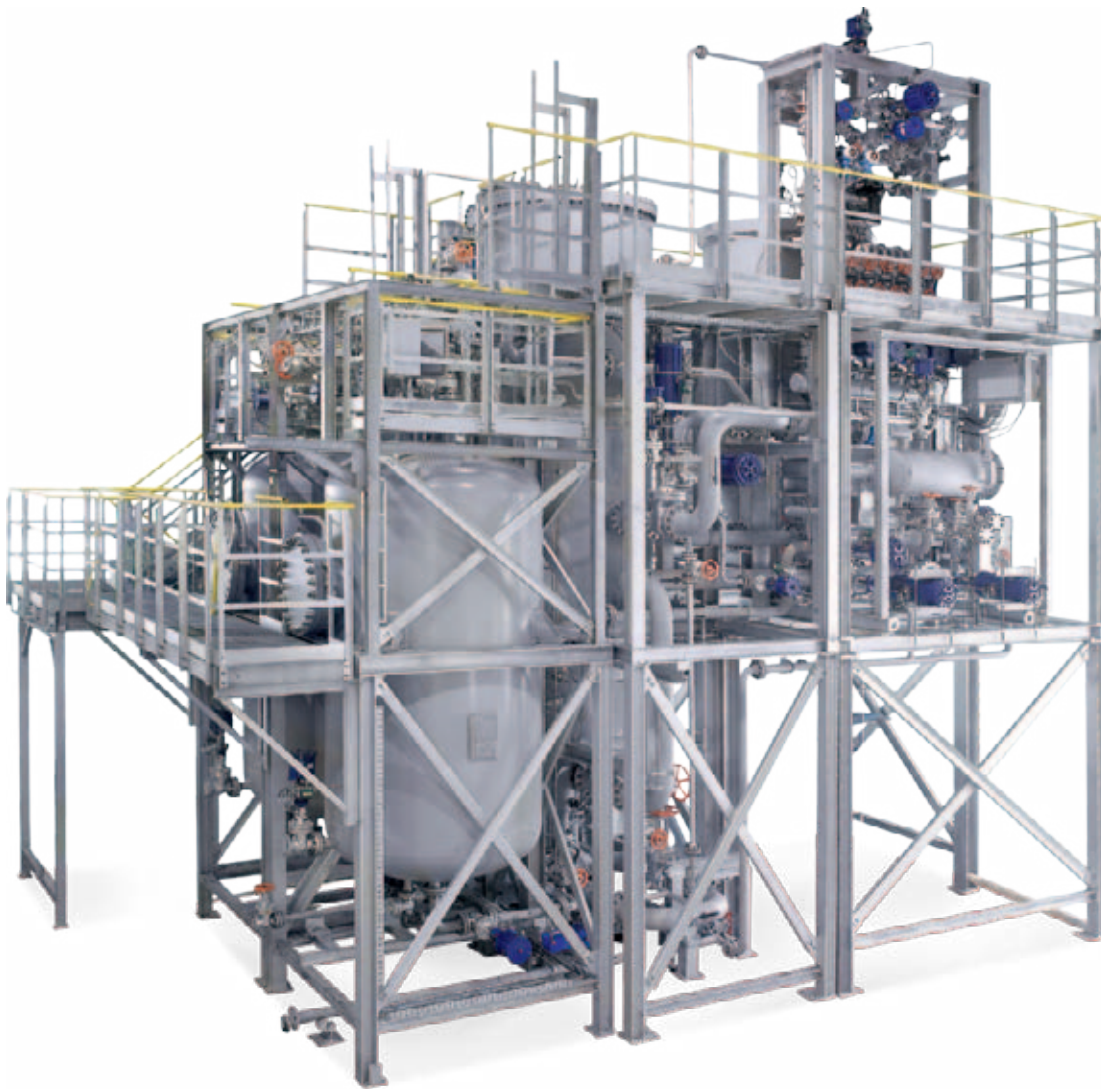
### Description of the application

In this application, the grey water from the gasifier contains coal fines and catalyst fines. These fines are sent to the wastewater plant while the clean water, with particles removed to less than 0.5 microns, is returned to the gasifier. The candle filter is designed for 182 m<sup>3</sup>/h (800 gpm) and produces concentrated slurry from an initial concentration of 0.2% solids. The wastewater plant is then only required to treat a much lower rate of the concentrated slurry every four hours rather than the 182 m<sup>3</sup>/h (800 gpm).

### Testing for filtration rate and sizing

The flux rate of the gasifier grey water slurry through the BHS test filter at a feed pressure of 2 bar (30 psig) is 1.5 m<sup>3</sup>/m<sup>2</sup> h (6.45 gpm/m<sup>2</sup>). The filter media is a proprietary PTFE membrane filter media to retain particles 0.5 microns and smaller. The filter cycle is defined by the time it takes to build a differential pressure of 1.7 bar (25 psi) across the filter membrane. For a capacity of 182 m<sup>3</sup>/h (800 gpm), the required filter area is approximately 135 m<sup>2</sup>. The design, including a safety factor, is three filter units, each with 66 m<sup>2</sup> of filter area. The operation is that two units are in operation while the third unit is in the discharge mode.





This modular liquid clarification system consists of one candle filter, one pre-coat tank, two activated carbon adsorbers and one polishing filter as main components in a gas processing plant. The PLC control system with communication back to the refinery DCS was designed by BHS.

## Regeneration of lean amine in a gas desulfurization process

### Description of the application

MDEA is used in an "Amine Sweetening Process" to capture  $\text{CO}_2$  and  $\text{H}_2\text{S}$  in an acid removal process. The lean amine is to be regenerated via activated carbon adsorbers, and pre-coated candle filters. The candle filters are used to prevent suspended solids from clogging the adsorber and to keep the rate of solids low enough to avoid foaming in the scrubber. The total flow to the candle filter is  $143 \text{ m}^3/\text{h}$  (630 gpm) from which a slip stream of  $43 \text{ m}^3/\text{h}$  (189 gpm) is sent to the activated carbon (AC) adsorbers.

### Testing for filtration rate and sizing

The design base of the lean amine filtration via the precoated candle filter is based on experience and a specific rate of  $2 \text{ m}^3/\text{m}^2 \text{ h}$  ( $8.8 \text{ gpm}/\text{m}^2$ ), thus resulting in  $71.5 \text{ m}^2$ . The chosen candle filter has  $78 \text{ m}^2$  and is designed for a maximum operation pressure differential of 8 bar g (120 psig), equipped with a polypropylene filter media with the use of precoat to capture the 95%  $> 1 \mu$  of the solids. The activated carbon filters are based on a max flux rate of 0.2 cm/sec and a residence time of 20 min. A 50:50 split stream is feeding two identical AC adsorbers with 2 m diameter and a bed height of 2.4 m.

# BHS candle filter technology

## Technology of clarification & recovery of slurries

Candle filters are installed for clarification and recovery applications from liquids with low solids content. They provide clean fluids to 0.5 micron with either a dried cake (no free liquids) or concentrated slurry.

### Description and operation of the candle filter

The BHS candle filter provides for thin-cake pressure filtration, cake washing, drying, reslurry and automatic discharge in an enclosed, pressure vessel. Candle filter systems are available up several hundred square meters of filter area.

### Filter candles & media

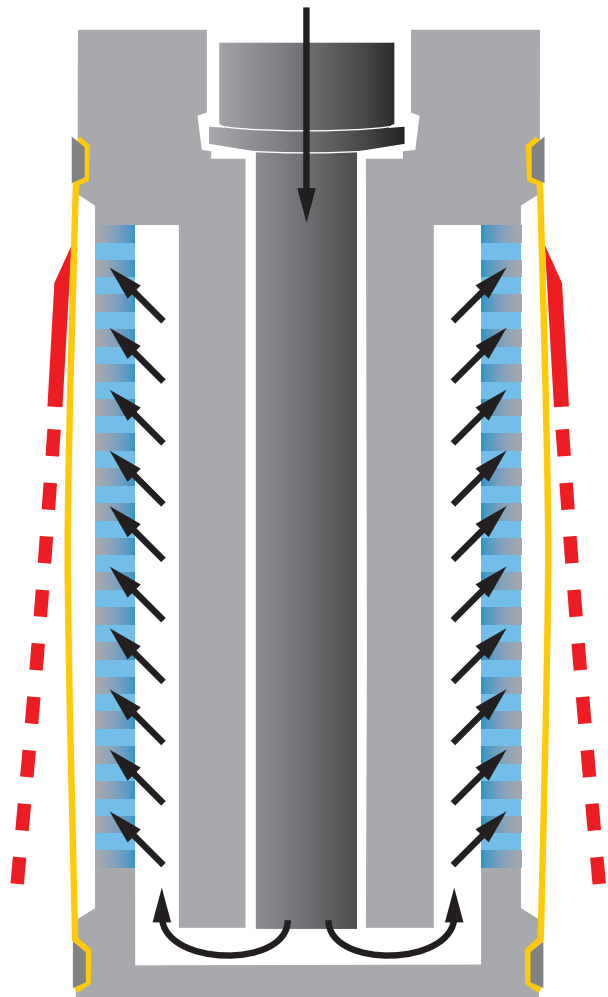
The filter candles **1** consist of three components: single-piece dip pipe for filtrates and gas, perforated core with outer support tie rods and filter sock media. The filtrate pipe is the full length of the candle and ensures high liquid flow as well as maximum distribution of the gas during cake discharge. The perforated core can be a synthetic material, stainless steel or alloy and is designed for the full pressure of the vessel. The outer support rods provide for an annular space between the media and the core for a low pressure drop operation and efficient gas expansion of the filter sock for cake discharge. Finally, the synthetic filter media has a removal efficiency to less than 0.5 microns.

### Filter vessel & candle registers for dry cake discharge

Vessel is constructed of stainless steel, alloy or carbon steel lined. Within the vessel are candle registers. Each candle is connected to a register with a positive seal to prevent bypass. Each register may contain from 1-20 candles depending upon the filter size. The registers convey the liquid filtrate as well as the pressure gas for filter media expansion. Each register is controlled with automated valves to ensure optimum flow in both directions. Picture **2** illustrates the candle filter vessel.

### Automatic process cycles

- [1] Filling: The slurry feed enters the bottom of the filter vessel.
- [2] Filtration: The slurry is pumped under pressure into the vessel. Cake will deposit on the outside of the candle; the separated filtrate will flow through the filtrate pipe and the registers. This process continues to a maximum pressure drop, the maximum cake thickness, or the minimum flow.
- [3] Washing: Displacement washing or recirculation washing.
- [4] Drying: Blowing gas, steam or "shock" drying.
- [5] Cake discharge: Gas flows through the register pipes, and down the filtrate pipe. The filter media gently expands allowing for cake discharge. Alternatively, the cake can be discharged as a slurry via a tubesheet design shown in picture **3**.



**1** BHS filter candles showing cake discharge.



**2** BHS candle filter are designed for dry cake discharge and illustrate the candle filter vessel.



## Function & process

### Operation

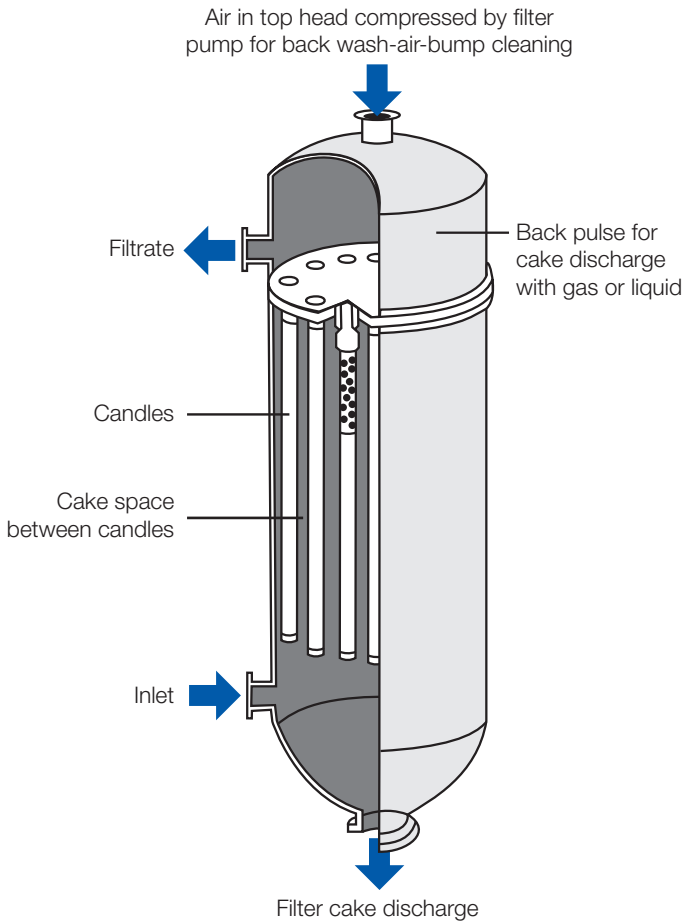
The BHS candle filter (CF) separates solids from liquids. In a pressure vessel, vertically arranged filter candles are equipped with a textile filter cloth. The suspension is fed into the vessel by a pump, creating a maximum pressure differential of up to 10 bar g (150 psig). The pressure differential pushes the suspension through the candles leaving the solids on the surface of the filter cloth and slowly building up a filter cake. The clear filtrate passes through the internal filtrate pipe in each candle and is collected either through a tube sheet plate or manifolded registers and then exits the vessel. The register arrangement allows for drying and individual control for cake discharge. The tube sheet design is used for the thickening and concentrated discharge. The BHS CF is operated either in a batch filtration mode or in a continuous mode with multiple units as a polishing filter, thickener or for clarification. The solids can be washed depending upon the process requirements and discharged as a thickened or concentrated sludge or pre-dried as a crumbly filter cake.

### Filter candle design

The filter candles are made of 316 L stainless steel or polypropylene. For special applications, candles are manufactured in Duplex 2205, Super-Duplex 2507, SMO 254, PVDF, CPVC and other materials. The design temperature and pressure are determined by the materials selected for the candle and filter cloth as well as by the type of operation. BHS candles are available in different designs based upon the type of cake discharge (dried or thickened and concentrated). For all designs, the filter cloth is fixed in-place at the top and bottom of the candle by a special fixing device. The unique design with a large open cross-sectional area in the candle allows for good adhesion of the solids during filtration, high filtrate flow rate and maximum cake release from the cloth during discharge. Cake discharge is either by low pressure gas to gently expand the filter cloth or by liquid or gas back flush for concentrated slurry.

### Application packages for candle filter systems

The strength of BHS is to analyze the process and provide a turnkey solution. The packages for BHS candle filter systems have various designs with solids feed concentration up to 5% and flow rates up to 200 m<sup>3</sup>/h (880 gpm) and higher. Filtrate clarity can be as low as 0.1 microns and below 5 ppm. For example, BHS has installed single candle filter units or multiple units, up to six candle vessels for continuous operation. Some processes require precoat and body feed while others may have activated carbon adsorption included. Finally, BHS has the unique ability to combine our other BHS technologies including candle filter units (CF) with BHS pressure plate filter (PF), indexing belt filter (BF) and rubber belt filters (BFR). Polishing bag and cartridge filters and filter presses can complete the system, as required.



3 Tube sheet design for concentrated slurry discharge.



Headquarters of BHS-Sonthofen with production in Sonthofen (Allgäu)

## BHS product and service range:

### Mixing technology

- Twin-shaft batch mixer
- Twin-shaft continuous mixer
- Single-shaft continuous mixer
- Laboratory mixer
- Mobile concrete mixing plants
- Continuous concrete mixing plants
- Retrofitting concrete mixing plants
- Mixing plants for the waste disposal sector

### Crushing technology

- Impact crusher & impact mills
- Rotor impact mill
- Rotor centrifugal crusher
- Mobile crushing plants
- Stationary aggregates plants

### Recycling technology

- Impact crusher & impact mills
- Rotor impact mill
- Rotor centrifugal crusher
- Rotorshredder
- Biogrinder
- Recycling plants

### Filtration technology

- Rotary pressure filter
- Indexing belt filter
- Rubber belt filter
- Autopress
- Candle filter
- Pressure plate filter
- Lab filters & pilot filters
- N<sub>2</sub> circuit for filters
- Filtration plants

### Worldwide service

- Tests in our BHS technical center
- Engineering – process engineering & consulting
- Spare parts & service



# BHS

## SONTHOFEN

EXPERIENCE AND INNOVATION

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