

4.1.1 **Kieselguhr (diatomaceous earth) filtration**

Kieselguhr filtration is the most common filtration method in the fruit juice industry. It is used for filtering juice, fining sludge and semi-concentrates.

Besides the filter systems or types of filter apparatus, the filter aid used such as kieselguhr, perlite, cellulose and special filtration additives like BECOFLOC are very important for optimum filtration efficiency. The application of these filter aids is described below. Furthermore, Begerow has prepared information sheets containing extensive technical data on the various products. These can be obtained from Begerow directly or from your local area manager.

Technical Information	Index Number
– Product survey BECOGUR	1 A 1.3.1.1
– BECOGUR 100	1 A 1.3.1.2.1
– BECOGUR 200	1 A 1.3.1.3.1
– BECOGUR 1500	1 A 1.3.1.4.1
– BECOGUR 3500	1 A 1.3.1.5.1
– BECOGUR 4500	1 A 1.3.1.6.1
– Product survey BECOLITE	1 A 1.3.2.1
– BECOLITE 3000	1 A 1.3.2.3.1
– BECOLITE 4000	1 A 1.3.2.4.1
– BECOLITE 5000	1 A 1.3.2.5.1
– BECOCEL	1 A 1.3.3.6
– BECOFLOC	1 A 1.4.1.1
– BECO Depth Filter Sheets Standard Series	1 A 2.2.2
– BECO Depth Filter Sheets Wine Series	1 A 2.1.2
– BECO Support Sheet KG 0/400 steam-proof	1 A 2.3.1
– BECO Support Sheet KG 0/400 hot water-proof	1 A 2.3.2
– BECO Module Filter Housing	1 A 2.5.5

Complete degradation of colloids, temperature (viscosity), amount of sediment and desired grade of clarification are important factors for the quality of the beverage. The filtered product should normally be stable and clear, whereby the stability of the juice depends essentially on the enzyme treatment, the fining process and proper storage.

The grade of clarification is determined by the further use of the product. An international standard used in this context is the NTU or FTU value. For example, apple juice concentrates which are traded internationally are often only acceptable with a maximum turbidity value of 2 NTU. The following values serve as a rough guide for classification according to degree of turbidity:

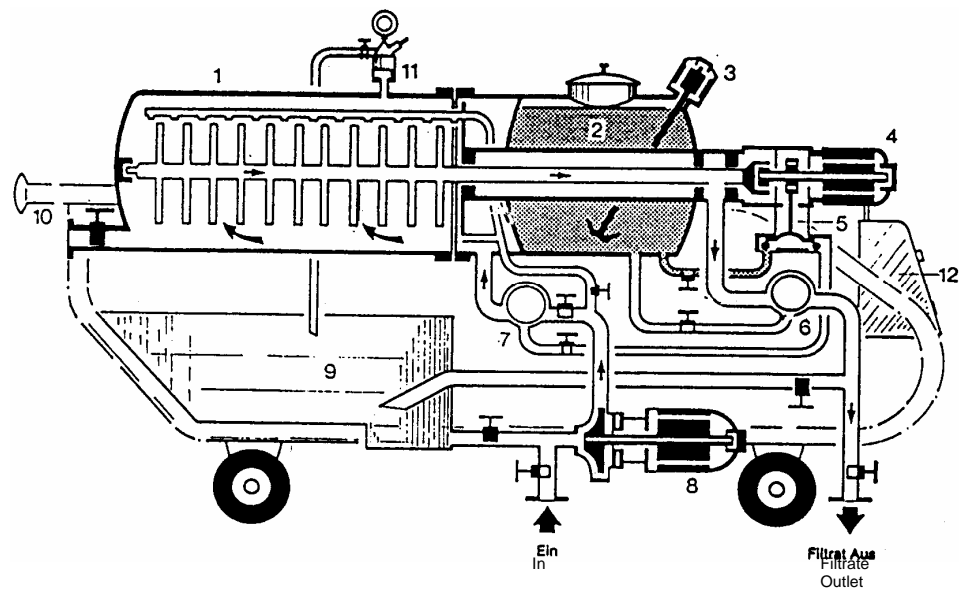
Turbidity definition	NTU value
absolutely clear	0 -1
clear	1.1 - 2.0
opalescent	2.1 - 2.5
slightly turbid	2.6 - 5
turbid	5.1 - 10
very turbid	10.1 - 20
extremely turbid	over 20

The most commonly used types of kieselguhr filters are vessel filters with vertical or horizontal screen elements, the rotary vacuum filters for large companies and the chamber filter presses for medium-sized and smaller fruit juice producing companies.

4.1.1.1 Horizontal screen filter with vertical screen elements

The horizontal screen filters with vertical screen elements (see illustration) have the advantage that the screens can be precoated on both sides with kieselguhr. This means that a larger surface is available for the same filter vessel size. The horizontal screen filter is in an ergonomically favourable working position, is easy to open and to clean. Smaller filters can be cleaned manually, while larger filter types feature automatic cleaning. The discharged filter cake is relatively dry, especially if it is discharged manually.

Fig. 1: Horizontal screen filter with vertical screen elements



A disadvantage is that precoating is sometimes uneven and the deposited kieselguhr cake is very sensitive to pressure drops or vibrations, which can dislodge the kieselguhr and thereby terminate the filtration process. A further disadvantage is that the filter cannot be completely emptied at the end of filtration, so that a certain amount of unfiltered product is left over. Consequently, these filter types are now rarely considered when companies invest in new apparatus. This type of filter is manufactured chiefly by the companies Padovan and Cuccolini.

4.1.1.2 Vertical screen filters

Vertical screen filters are kieselguhr filters which have an upright housing with screens arranged vertically or horizontally.

4.1.1.2.1 Vertical screen filter with vertical screen elements

This filter type is found relatively often in the fruit juice industry.

Benefits:

- The screen plates are precoated on both sides.
- To obtain the same square metres of filter (screen) surface the filter housing can be smaller in size.
- Dry discharge of the kieselguhr cake is possible.
- The filter is relatively inexpensive.
- The filter package can be dismantled relatively quickly.

Disadvantages:

- The kieselguhr cake tends to fall down easily in the event of sudden pressure changes or interruptions of the filtration process.
- The maximum cake volume is lower than with horizontal plates.
- The filtration cycles are shorter.
- Changing over to a new product is difficult.
- At the end of filtration the liquid remaining in the filter has to be filtered off using an additional filter.

Manufacturer: Cadalpe

4.1.1.2.2 Vertical screen filter with horizontal screen elements

These are the most commonly used filter types.

Fig. 2a: Vertical screen filter with horizontal screen elements

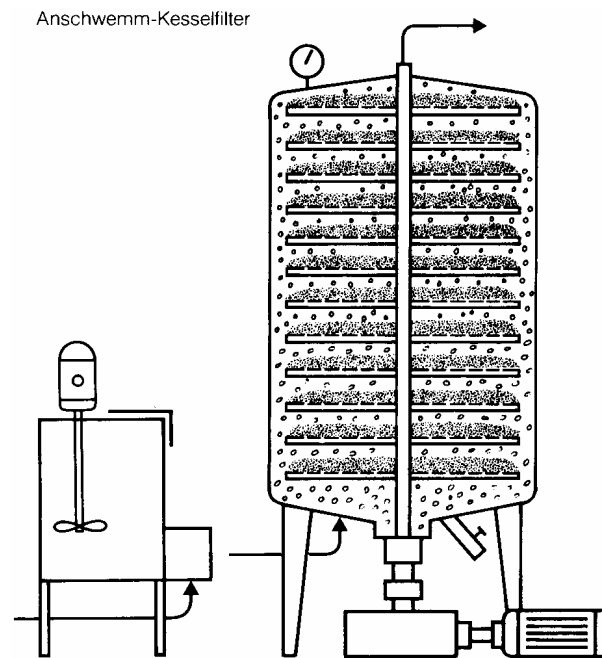
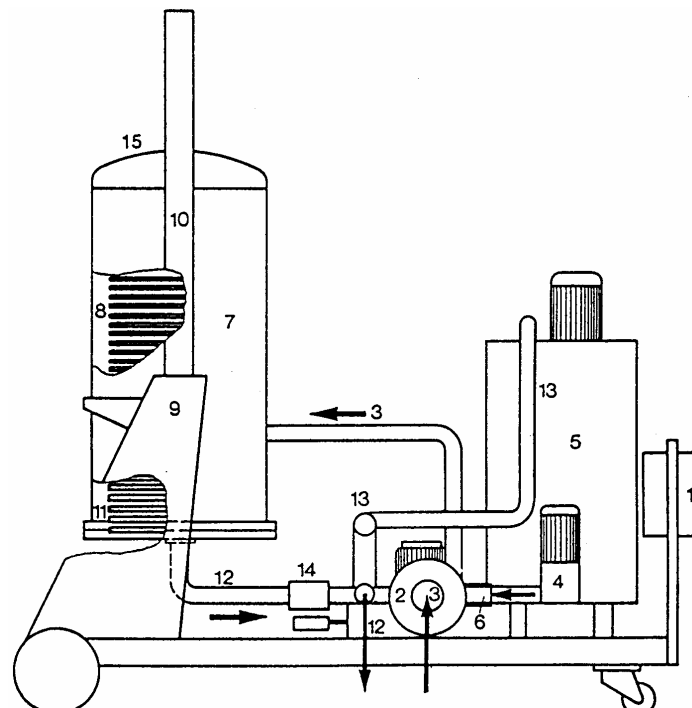


Fig. 2b: Vertical screen filter with horizontal screen elements



Benefits:

- Good stability of the kieselguhr cake.
- Precoat application using water is possible.
- Long filtration cycles.
- Change of product without mixing of products.
- Filtration of remaining product by means of a special screen element at the base of the filter.
- Dry discharge of the kieselguhr cake.
- Low water consumption for cleaning.

Disadvantages:

- Only one side of the screen element can be precoated with kieselguhr.
- Risk of residual kieselguhr being left on the filtrate side of the screen (as a result of the cleaning process).

4.1.1.3 Recommendations for optimum filtration using screen filters:

- Before starting precoat filtration, the thoroughly cleaned filter must be well de-aerated. The juice used for the precoat application must be as clear as possible. As an alternative, water can be used for the precoat application.
- The dosing tank is integrated into the precoating cycle, i.e. a dosing pump is not used.
- During pre-coating the pump capacity is 50-100 % higher than the subsequent rate of filtration.
- During precoating and filtration a counter-pressure of at least 0.5 bar should always be maintained.
- For application of the precoat a quantity of 1,200 - 1500 g/m² medium-coarse kieselguhr, e.g. BECOGUR 3500, should be used. The same kieselguhr should be used for the body feed.
- However, if a finer kieselguhr is to be used for filtration in order to enhance the filtration efficiency, a second precoat is necessary. The first precoating cycle consists of approx. 500 - 600 g/m² medium-coarse kieselguhr, e.g. BECOGUR 3500, followed by secondary precoating with approx. 700 - 1000 g/m² of the kieselguhr which is also to be used in the body feed, e.g. BECOGUR 1500 or BECOGUR 200.
- Dosage: Depending on the product and turbidity, and on the desired grade of clarification, the kieselguhr dosage must be flexible and adapted to the grade of clarification. Fresh juice is normally easier to filter than juice which has been stored for a prolonged period. The average consumption of kieselguhr is 120 g/hL. However, juices which are difficult to filter may easily require 300 - 400 g/hL. Immediately before changing the tank of unfiltered product the kieselguhr dosage should be increased to compensate for the briefly higher turbidity. Ideally, the hourly increase in the differential pressure should be 0.2 to 0.3 bar.
- The filter must not be overloaded with filter aids (kieselguhr). Always follow the manufacturer's instructions as regards sludge holding capacity.

- With juices a m² capacity of up to 2,000 L is possible.
- Semi-concentrated and concentrated juices (hot) must be filtered slower on account of their viscosity.
- Substitute for kieselguhr
- Perlite:
For a more economical process, kieselguhr can be partly replaced by perlite. Perlite has a lower filtration effect and forms a less stable cake. A maximum quantity of perlite of 20 weight percent, e.g. BECOLITE 5000, should not be exceeded.
- Cellulose:
Should the screen elements or the seals between the screen elements be defective, it is often possible to achieve an improvement by means of a basic precoat of cellulose (BECOCEL 200 - approx. 200 g/m² -) prior to the actual kieselguhr. This often makes the defective screens or seals tight again.
- Filtration additive BECOFLOC:
BECOFLOC is a positively charged, granular and fibrous filter aid to improve filtration efficiency. If added in the basic and secondary precoat application, the reinforcement and stability of the cake is significantly improved. The filtrate is less turbid. The standard application quantity is 20 g/m² for the basic precoat and 30 g/m² for the secondary precoat.
- If added in the body feed (1-2 g/hL) it is usually possible to save on kieselguhr and in addition to improve the grade of clarification.

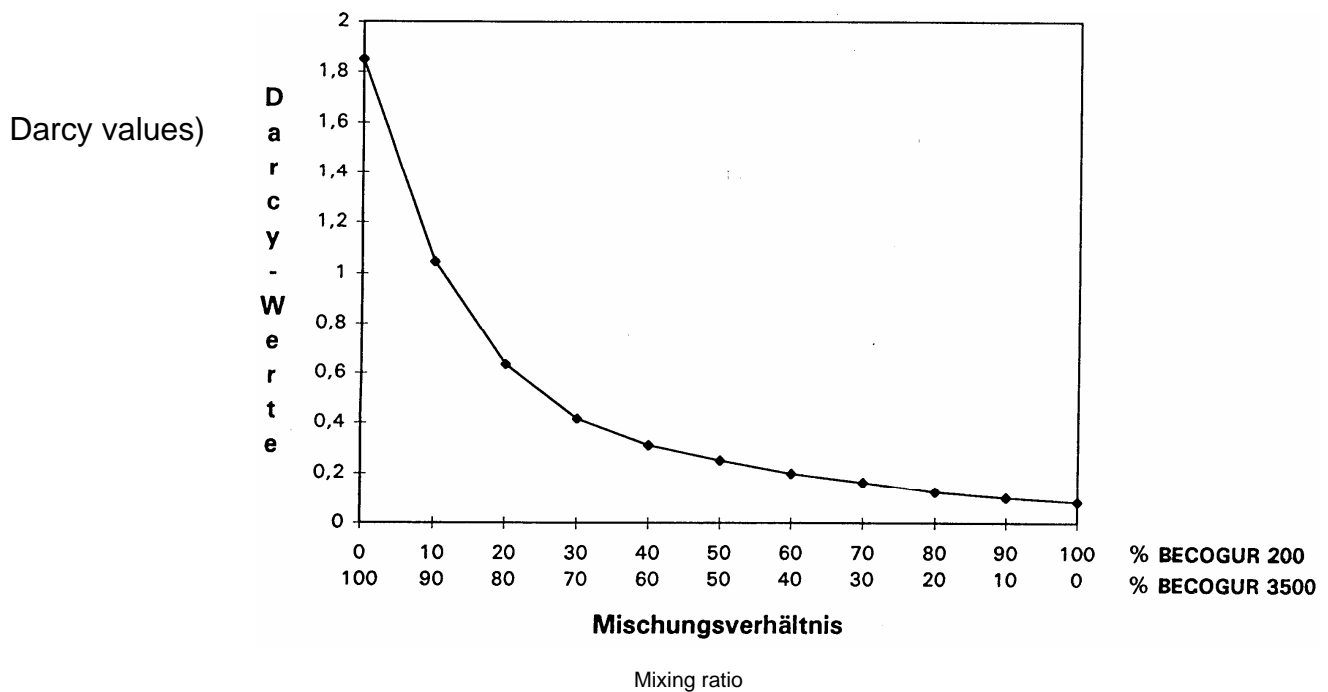
Classification of kieselguhr

Kieselguhrs are classified in terms of fineness and retention characteristics on the basis of their permeability, which is measured in Darcy. Darcy is an international unit used to define the permeability of a filtering medium: Water is pressed through a cube of kieselguhr having an edge length of 1 cm (i.e. a volume of 1 cm³) at a pressure of 1 m water head. The flow rate is recorded and specified in mL/s. The permeability of kieselguhr is graded according to the following values (according to the EBC Routine Method):

Kieselguhr	Darcy
Fine	0.03 - 0.07
Medium	0.1 - 0.5
Medium-coarse	0.75 - 1.5
Coarse - very coarse	1.5 - 11

The permeability of the kieselguhr(s) used has a direct influence on the grade of clarification and total throughput. To adjust the ideal mixing ratio, a great deal of practical experience is required. Fig. 3 indicates the possibility of controlling the permeability and thus the filtration efficiency by mixing medium-coarse BECOGUR 3500 with fine BECOGUR 200. The limiting factors in this are the desired grade of clarification and the pressure increase

Fig. 3: Darcy values of BECOGUR mixtures



Kieselguhr holding capacity

Each kieselguhr filter has a limited kieselguhr holding capacity which is specified by the filter manufacturers in "litres of sludge volume". As the application quantity of kieselguhr is dosed in weight units, the wet density of the filter aid has to be considered when determining the maximum permissible kieselguhr holding capacity.

The filter aids sold by Begerow have the following wet density, from which the specific kieselguhr holding capacity can be calculated:

BECOGUR	100	200	1500	3500	4500
Wet density	310 g/L	350 g/L	350 g/L	340 g/L	310 g/L
Spec. BECOGUR volume	3.2 L/kg	2.9 L/kg	2.9 L/kg	3.0 L/kg	3.2 L/kg

BECOLITE	3000	4000	5000
Wet density	200 g/L	175 g/L	150 g/L
Spec. BECOLITE volume	5.0 L/kg	5.7 L/kg	6.7 L/kg

To ensure that the sludge volume is not exceeded and the filter elements are not damaged, the given filter aid quantity should be approx. 10 % below the theoretically determined quantity.

Example of calculation:

The maximum permissible sludge volume specified by the filter manufacturer is 90 litres. The filter aid used is BECOGUR 3500 with a specific volume of 3.0 L/kg.

$$\frac{90 \text{ L sludge volume}}{3 \text{ L/kg specific BECOGUR volume}} = 30 \text{ kg kieselguhr}$$

30kg kieselguhr - 10 % safety margin= 27 kg kieselguhr.

Therefore, for a filter with a sludge volume of 90 litres the maximum quantity of BECOGUR 3500 which can be used is 27 kg.