TECHNICAL DATA

Filter-Anthrazit N

... is mainly used in multi-layer filtration for

removing iron and manganese

fine filtration

e.g. after softening or rapid decarbonization

removal of suspended solids and turbidity

e.g. for the removal of microscopically small algae from reservoir water in the course of drinking-water treatment

e.g. for decreasing the phosphate loading of eutrophicated waters through flocculation-filtration processes

e.g. for protecting activated carbon filters, ion exchangers and reverse osmosis plants

e.g. for advanced waste water treatment in wet- or dry-bed filters.

Filter-Anthrazit N can also be used as the sole material in a filter when the water quality requirements e.g. for preparing boiler water free of SiO_2 must be fulfilled.

Filter-Anthrazit N also simplifies the regeneration of activated carbon filters when included as a supportive layer.

Filter-Anthrazit N

Chemical analysis

carbon	about 90 %
moisture	about 1 %
ash	about 3.5 %
volatile matter	about 5.5 %

Characteristics

bulk density	about 730 kg/m³
density	about 1.45 g/cm³
grain porosity	< 10%
hardness	about 4 Mohs 32° Hardgrove

Standard grain sizes

Type	Grain Size
1	0.6 – 1.6 mm
2	1.4 – 2.5 mm
3	2.0 – 4.0 mm
4	3.5 – 7.0 mm

Other ranges of grain size can be supplied in accordance with individual requests.

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Technical Pamphlet 1

Filter-Anthrazit N

... is natural, crushed, pure anthracite.

Anthracite is a form of carbon which arose following a series of metamorphic changes of plant material:

wood – peat – lignite – coal – anthracite.

This hard, angular, shiny-black material has a chip-like appearance and is sieved into narrow ranges of grain sizes for use as a filter material. Filter-Anthrazit N is mainly employed in multi-layer filtration (e.g. Filter-Anthrazit N above filter sand) but its use as the sole filter material can also be of advantage.

Filter-Anthrazit N in rapid gravity and pressure filters serves to filter water containing suspended solids and turbidity in the fields of drinking-water, process water and wastewater treatment. It is also used in the water purification process for swimming pools.

Filter-Anthrazit N promotes

- an improvement in the filtration efficiency
- a decrease in the uncertainty of filter breakthroughs
- a saving of washwater
- an increase in the filtration velocity
- a lengthening of the filter run

Natural anthracite is specified as a filter material in numerous standards:

1. DIN 2000 (4.9.4.2)
2. DIN 19605 (4.3.8)
3. DVGW-Arbeitsblätter (technical pamphlets) W 210 (4.1.3) and W 211 (4.2)
4. DIN 19643 (7.2.2.2)
5. ÖNORM M 6216 (2.3.1.2)
6. ÖNORM M 6220 (6.2)
7. ANSI/AWWA B 100 – 89 (2.3)

Filter-Anthrazit N irrefutably fulfills the requirements in § 31 (1) of the German Food and Food Utensils Act of 15.08.1974 (BGB1 I, 1974, No. 95, p.1945) which specifies the harmlessness to human health. This has been confirmed with thorough examinations conducted by the Institute for Hygiene, Gelsenkirchen in 1980 and 1987.

Material data

Bulk volume	c. 1.37 m³/t
Bulk density	c. 730 kg/m³
Density	c. 1.45 kg/dm³
Grain porosity	< 10 %
Hardness	c. 4 Mohs c. 32° Hardgrove Index
Attrition loss with dust formation	c. 0.25 % + 0.05 %

Attrition loss is determined with 800 ml of subsize particle-free, wetted material in water after blowing air through at 75 m/h for 20 h. The portion of particles smaller than 0.1 mm is classified as dust.

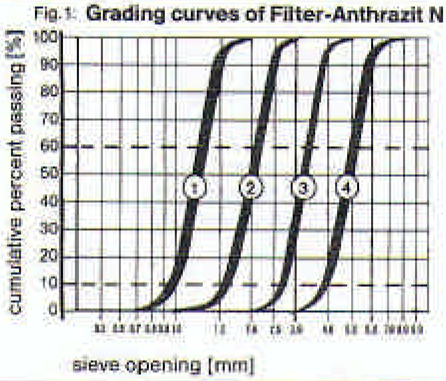
Standard grain sizes

type	grain size range	effective size d_{10}	uniformity coefficient $U = d_{60}/d_{10}$
1	0.6 – 1.6 mm	0.9 – 1.0 mm	≤ 1.4
2	1.4 – 2.5 mm	1.5 – 1.6 mm	≤ 1.4
3	2.0 – 4.0 mm	2.6 – 2.7 mm	≤ 1.4
4	3.5 – 7.0 mm	< 4.0 mm	< 1.5

The portion of over- and undersize particles is in each case less than 5 % in accordance with the German standard DIN 19623 "Filter Sands and Filter Gravels for Water Purification Filters".

Filter-Anthrazit N with the grain size range of 3.5 – 7.0 mm is normally used as a supportive layer in mono-medium anthracite filters.

Fig. 1: **Grading curves of Filter-Anthrazit N**



Combinations of media and grain sizes

for dual-media filters are recommended on the grounds of investigations by several research institutes and experience gained from existing units:

Filter material	Grain grade combinations I	II	III
Filter-Anthrazit N	0.6 – 1.6 mm	1.4 – 2.5 mm	2.0 – 4.0 mm
Filter sand	0.4 – 0.8 mm	0.71 – 1.25 mm	1.0 – 2.0 mm alternatively 1.0 – 1.6 mm, 1.5 – 2.2 mm
Support layers* consist. of filter sand/gravel	1.0 – 2.0 mm (2.0 – 3.15 mm) 3.15 – 5.6 mm	2.0 – 3.15 mm (3.15 – 5.6 mm) 5.6 – 8.0 mm	3.15 – 5.6 mm (5.6 – 8.0 mm) 8.0 – 12.0 mm

* If necessary or required depending on the construction of the filter floor and the width of the filter nozzles.

Depth of the filter sand layer at least 300 mm.
Depth of the individual supportive layers about 150 mm.

The **depth of the filter material** in mono- or dual-media filters is dependent on the filtration velocity, the physical and chemical composition of the water to be treated and the purpose of the treatment.

In order to achieve an optimally functioning filtration process, the depth of the filter layer should not be less than the following recommendations:

- mono-medium filter (only Filter-Anthrazit N) — at least 500 mm
- multi-media filters (Filter-Anthrazit N as the upper layer) — at least 300 mm

The depth of each filter medium for the combination I and II used for the filtration of swimming pool water is given in the German standard DIN 19643, table 5:

Filter material	rapid gravity filters	pressure filters
Filter-Anthrazit N Filter sand	at least 400 mm at least 600 mm	at least 600 mm at least 600 mm

The **filtration velocity** can be

- 3 – 15 m/h in rapid gravity filters
- 10 – 30 m/h in pressure filters
- up to 50 m/h in special cases (e.g. for swimming pool water and whirlpools)

due to the hydraulics of each system.
It is dependent on the condition of the raw water, the quality of the filtrate required, the composition of the filter bed and economical aspects. The water flow at the inlet to the filter must not disturb the filter material layer!

The **pressure loss** of a clean filter layer is dependent on the filtration velocity, the grain size and depth of the filter medium and the water temperature. The pressure loss increases with increasing loading i.e. it is proportional to the total amount of matter retained in the filter. Backwashing removes the substances retained by the filter and the pressure loss in the clean filter is restored to the original value. The pressure loss Δp_f in a 1 m layer of clean Filter-Anthrazit N in relation to the filtration rate is shown for the different grain size ranges in figure 2.

The units [mbar/m] and [cm water column/m] are very similar and are regarded as being equal (1 mbar = 1.0197 cm H_2O).

The pressure loss at temperatures other than 20°C can be calculated with a correction factor derived from the temperature dependent viscosity of the water:

$\Delta p_f = \Delta p_f\,(20°C) \cdot f_p$ (Value for f_p can be taken from the table "correction factors")

The **filter wash** serves the purpose of cleaning the filter material and restoring the full efficiency.

The backwashing of multi-media filters should be performed in such a way that at the end of the process the different filter media in accordance with their grain size and density lie as separate, consecutive, uniform layers. In order to achieve this, it can be of advantage to slowly shut off the wash water supply.

An "adequate" backwash velocity or fluidization velocity v_b' is considered to be the water velocity which sets and holds the whole filter bed in motion and which causes the individual particles of filter material to rub against each other. The matter filtered from the water in the course of filtration becomes detached from the filter material and is washed out of the fluidized filter bed. From the course of the pressure loss in relation to the backwash velocity, v_b' can be determined as the point of interception of the increase in pressure loss and the maximum pressure loss. The fluidization velocity v_b' needed for a grain diameter

Fig. 2: **Pressure loss (Δp_f) versus filtration rate (v_f)**
(clean Filter-Anthrazit N)

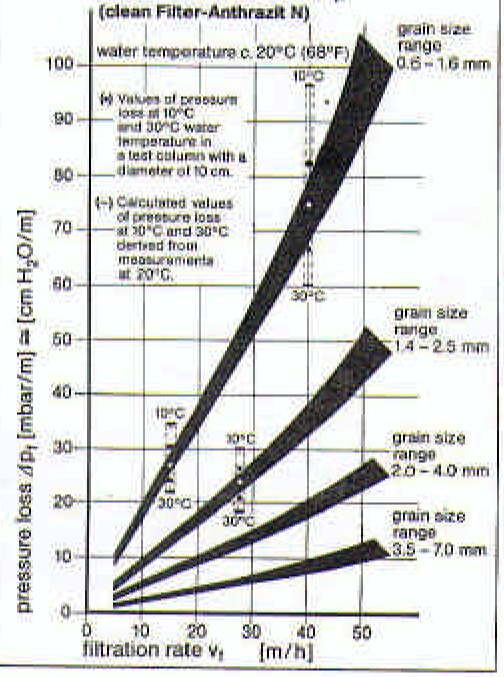
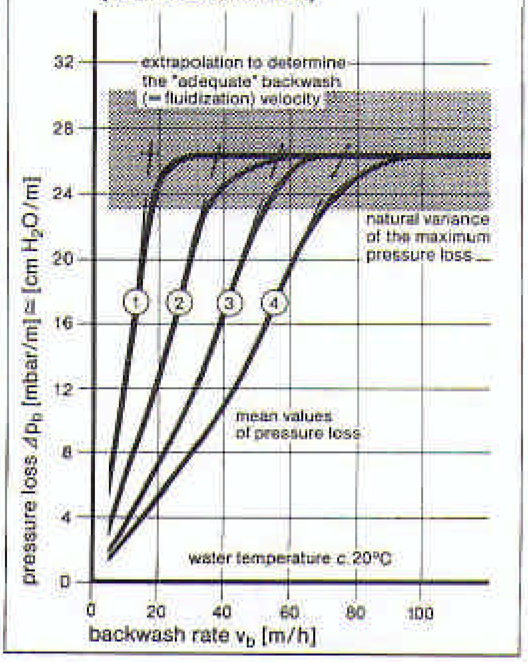


Fig. 3: **Pressure loss (Δp_b) versus backwash rate (v_b)**
(clean Filter-Anthrazit N)



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d_w can also be calculated for Filter-Anthrazit N (H.-G. Moll, gwf - wasser/abwasser 121 (1980) p. 15, H.-G. Moll, bbr 31 (1980) p. 519):

$$v_b^f = \sqrt{\left(\frac{59}{d_w}\right)^2 + 1630 \cdot d_w} - \frac{59}{d_w} \qquad d\ [mm] \quad v_b\ [m/h]$$

$$d_w = (0.75 + \sqrt{0.54 \cdot U - 0.48}) \cdot d_{10}$$

A relationship between washwater velocity and grain size has been described by Kawamura (Journal AWWA 67 (1975) p. 653) with which it is possible to determine the water backwash rate for maximum scouring in anthracite filters:

$$v_b^s = 28 \cdot d_{60}$$

Optimal shearing is obtained when a 90 % expansion of the filter bed is achieved during backwashing. Already 25 % expansion of the filter bed allows 93 % of the possible shear force to be effective. (H.-G. Moll, Proc. 4th World Filtration Congress, I (1986) p. 87).

The backwash velocity required to effect a 25 % filter bed expansion at 20°C with Filter-Anthrazit N of known grain size can be calculated with the good approximation formula:

$$v_b^{25\%} = 25 \cdot d_w + 36 \cdot (\sqrt{d_w} - 1)$$

By rule of thumb a doubling of the fluidization velocity is sufficient to give a 25 % filter bed expansion.

In the following table the order of magnitude of the different backwash velocities at 20°C are shown by a calculation of the grain diameter (d_w) and backwash rates with definite values for the effective size (d_{10}) and the uniformity coefficient U.

d_{10} [mm]	U	d_w [mm]	v_b^f [m/h]	v_b^s [m/h]	$v_b^{25\%}$ [m/h]
0.9	1.4	1.15	16	35	31
1.6	1.4	2.04	36	63	68
2.6	1.4	3.32	58	102	112
3.8	1.4	4.85	78	149	165

The backwash velocity at other temperatures can be approximately calculated when only the temperature dependent viscosity of the water is taken into account:

$v_b = v_b\,(20°C) \cdot f_v$ (Value for f_v can be taken from the table "correction factors")

Correction factors
for the backwash velocity v_b and the pressure loss Δp_f at other temperatures than 20°C:

T (°C)	5	10	15	20	25	30	35	40	45
f_v	0.87	0.92	0.96	1	1.04	1.08	1.12	1.15	1.19
f_p	1.52	1.30	1.14	1	0.89	0.80	0.72	0.66	0.60

In practice, a filter bed expansion of 20 % during washing is desirable in newer filtration plants.

This method of backwashing with high washwater velocity is particularly effective for cleaning the filter material. In spite of the high washwater flow rate compared with usual backwashing techniques, less backwash water is required because of the shorter duration of the backwash-cycle.

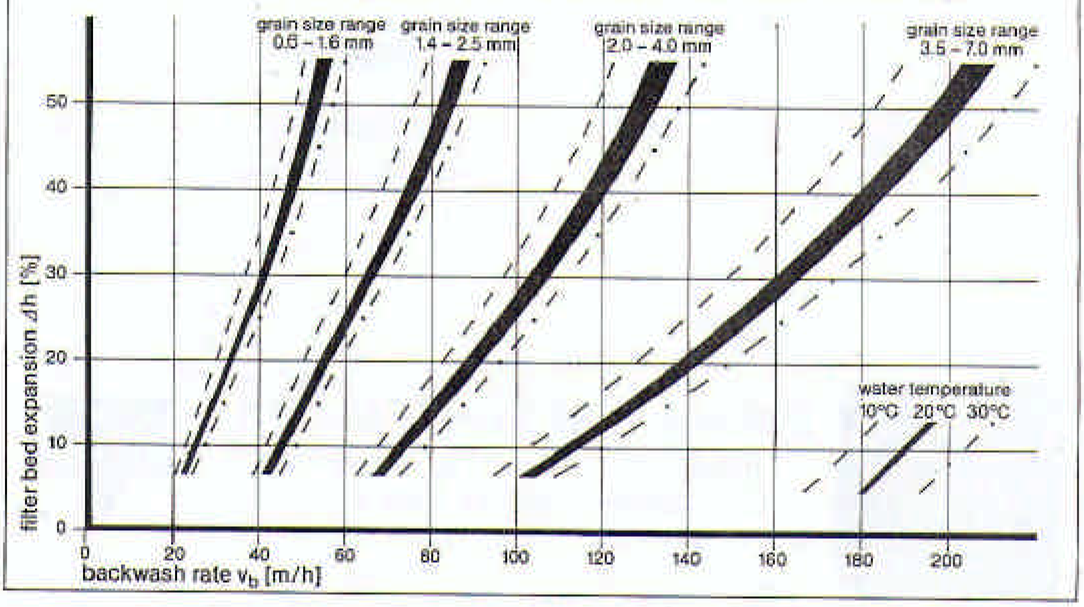
The values for the backwash rates given in the following table are applicable at 20°C and should be corrected for other temperatures.

Practical values for the backwash rate

type	grain size range	backwash rate
1	0.6 - 1.6 mm	35 - 40 m/h
2	1.4 - 2.5 mm	55 - 60 m/h
3	2.0 - 4.0 mm	85 - 95 m/h
4	3.5 - 7.0 mm	130 - 140 m/h

The backwash rate must always be high enough to remove all the accumulated matter from the filter medium, in which case the density and size of these substances are of prime importance.

Fig. 4: **Filter bed expansion (Δh) of clean Filter-Anthrazit N versus backwash rate (v_b)**



d_w can also be calculated for Filter-Anthrazit N (H.-G. Moll, gwf – wasser/abwasser 121 (1980) p. 15, H.-G. Moll, bbr 31 (1980) p. 519):

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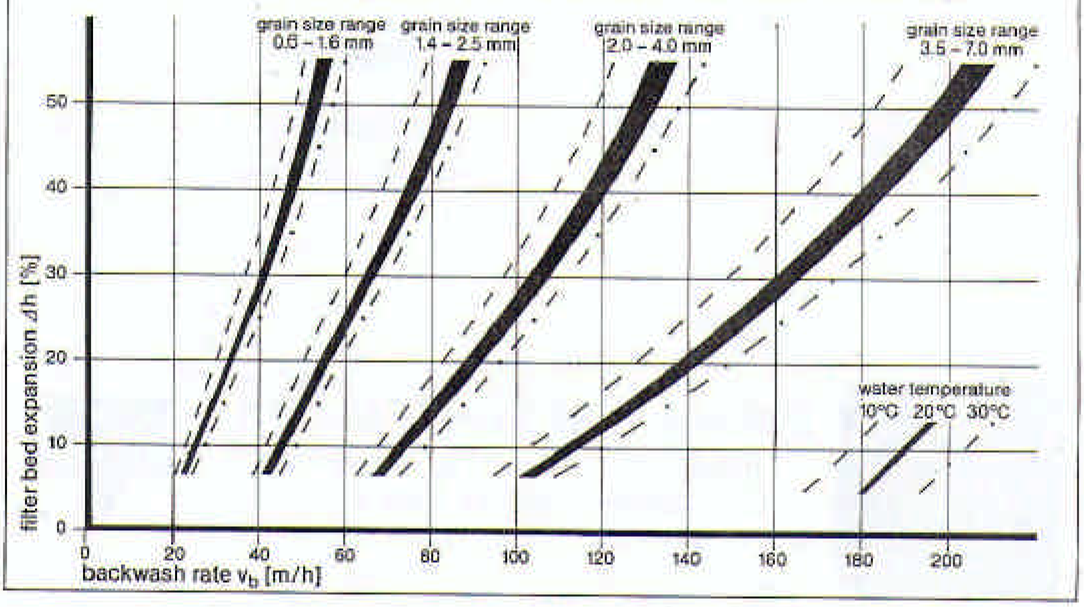

Backwash techniques

Backwashing with water only

This is often sufficient when loosely adhering accumulated matter needs to be removed.

Backwash rate see table "practical values".

Duration of backwash until the washwater effluent is almost clear.

Backwashing with air and water

This is necessary when accumulated matter needs to be removed which is firmly attached to the filter material particles. Air scouring alone serves to break clumps of filter material into individual particles. A simultaneous water flow improves the cleaning effect.

Before air scouring is started, the water level in the filter has to be lowered to just above the surface of the filter bed in order to avoid flushing away filter material.

Air and water (separately)

Air velocity: 60 – 90 m/h
Duration: about 1 – 3 minutes

Following treatment, a period of about 2 minutes should elapse to allow the air to dissipate from the filter bed before backwashing with water is begun. During backwashing, the water content of the filter should be replaced at least once (backwash rate: see table "practical values"; duration: until the effluent is almost clear). A long period of backwashing is of lesser importance for the cleaning effect. Better results are obtained by repeating the whole backwash-cycle with air and water as described above.

Air and water (combined)

Air velocity: 60 – 90 m/h
Duration: about 1 – 3 minutes

Following 1 – 2 minutes of air scouring with air only, treatment is continued with air and water.

Backwash rate: 7 – 20 m/h
Duration: about 3 – 5minutes

Thereafter, water only is used (backwash rate: see table "practical values"; duration: until the effluent is almost clear) to flush out the dislodged matter from the filter. In the case of multi-media filters the different layers are subsequently restratified with about 15 % higher backwash rate.

Special points for the backwashing

Multi-media filters which have a freeboard only designed to accomodate the bed expansion must not be backwashed with air and water simultaneously!

When the height of the freeboard is 2 m or more, combined water- and air-scouring can be used. In this case backwashing must be performed according to the manufacturer's specifications because the optimization of backwash rate and duration is limited by the available head.

When the filters are used for removing flocs, it can be of advantage to backwash with water before air scouring which removes a larger part of the flocs from the surface of the filter medium. This avoids a distribution of the dirt particles in the filter bed during air scouring.

In the case of the different layers of filter material becoming very mixed together, e.g. due to combined air/water backwashing, a restratification of the layers must be carried out by backwashing only with water at a velocity 15 % higher than the usual recommended rates.

The **height of the freeboard** should have an additional safety margin of at least 300 mm more than that expected from the backwash technique and the filter bed expansion (according to the DVGW technical pamphlet W 211 (3.2.2.1)).

Particularly with biologically assisted filtration processes, a period of ripening or seeding of the filter with ripened material may be necessary. Following such preparations, it may be purposeful to check the backwash specifications (backwash rate, duration...) and if necessary to optimize them. In the case of wastewater filtration, the required bed expansion will often be achieved with lower backwash rates than expected with fresh material.

An automated backwash program is desirable although the possibility of being able to make corrections for optimal running should not be disadvantageously effected.

The **delivery** of Filter-Anthrazit N is done in

- 50 l plastic bags
- 1.2 t big bags (about 1.65 m^3) or
- as bulk in silo lorries

Filter-Anthrazit N must be filled into the filter with water or be submersed in water. It can also be pumped over obstacles into the filter as a slurry in water through several meters of pipe.

Subsize filter material which may arise during transport into the filter can be removed by backwashing alone or scraped off after backwashing.