Backwashing

A) Backwashing of a Granular Filtering Media

It is very important to backwash properly a filter media as if not performed correctly, this would lead to permanent clogging of some of the filter areas which results in preferential flows through the filter bed and consequently a decrease in the filter efficiency. Backwashing a filter bed is achieved by introducing water sometime in conjunction with air at the bottom of the filter. The dirty water is evacuated from the top of the filter over one or two weirs or into several troughs.

A-1) Backwashing with Water Alone

When backwashing with water atone, it is necessary that a sufficient expansion of the filtering material is obtained. Efficient backwash with water alone is achieved with a minimum bed expansion of 15 % and 30% Bed expansion is recommendable if available.

The backwash flow to obtain a constant bed expansion is related to water temperature. This can be understood by the fact that the water viscosity varies according to the water temperature.

A bed in expansion is subject to convection currents. In certain zones the filtering material moves upwards and in other neighboring zones downwards. Because of this, positions of the compact layer of sludge encrusting the bed surface are carried downwards which may form what are called mud balls. For this reason, most first stage filters where the water is coagulated prior to be filtered, air is also utilized during the backwash operation to limit the negative effect of these convection currents.

A-2) Simultaneous Water and Air Backwashing

This type of backwash is ensured by backwash simultaneously with water and air, the wash water rate being limited so that the filter media is not brought into expansion. These operation washes the impurities accumulated in the filtering media into the water layer situated above the bed. This technique should **not** be applied for GAC due to the abrasiveness.

This water layer is then rinsed away

- either by continuing the water backwash after having stopped the air scour,
- or by sweeping the filter surface with a horizontal current (cross wash),
- or even by removing this water layer using siphon boxes.

A-3) Backwashing with Air and Water in Succession – Air Scouring and Backwashing

Air is injected first for a short period (2 to 3 minutes for Sand/Anthracite and less than1 minute for GAC) to detach the retained impurities like bacterial mass. Then water is injected at a sufficient rate to ensure the required expansion. The water flow will ensure the removal and carry over of the impurities detached during the first stage.

This Backwashing technique is used if there is a risk of carry over to drain of the filtering material. This is the case for fine sand, low density materials (anthracite and GAC) and multi-media filters. This technique can be sometimes applied after draining water below the top level of Sand/Anthracite or 15 to 20 cm above the top level of GAC.

B) Backwashing & Air Scouring of GAC Bed

Most GAC beds will require backwashing at the beginning and from time to time during operation. Backwashing is an upward flow of water through the adsorber causing an expansion in the GAC bed. The bed expansion ranges from 15 to 30 % with a typical recommendation of 20 to 25 %. The upward linear velocity to achieve this is given by a bed expansion graph. There are two types of backwash:

B-1) Initial Backwash

This is required after the delivery of virgin or reactivated GAC to remove air, fine particles and segregate the bed. The bed expansion should be ranged from 25 to 30 % for better segregation, however, this procedure **should be started at slow flow rate** (30 to 50 % regular flow rate) and normally takes 30 to 60 minutes (more than three times of the operational backwash described below). **Never utilize air scouring** for this initial backwashing. It should be noted that water soak should be required at least for one day after filling GAC and before starting this procedure in order to deaerate GAC completely.

B-2) Operational Backwash

This is normally required due to an increased pressure drop across the bed brought about by the build-up of filtered particles. The frequency of backwash will depend on the level of turbidity in the influent and the throughput of the adsorber. This is usually dependent on the source of raw water, treatment processes and whether it is a primary or secondary filter. For example, when treating high quality ground water sources, the back washing may be less than once per month where as a primary filter at a surface water treatment works may be backwashed several times a week. It is recommended to backwash an adsorber treating surface water every one to two weeks. For biological activated carbon, backwashing is an effective method of controlling the build up of biomass within the carbon bed. Typically, the backwash operation takes 10 to 20 minutes, which depends on bed volume and backwashing flow rate.

B-3) Air Scouring

GAC can be air scoured, but due to the abrasiveness of this technique, its use should be minimized. The suspended solids liberated by the air scour are removed from the filter by the subsequent backwash cycle.

Typical conditions for Air Scouring GAC

Maximum linear velocity	50 - 60 Nm/h
Maximum time	1 minute
Water level	15 - 20 cm above the bed

In case where Air Scouring is applied, backwashing **should be followed at slow flow rate** (about 50 % regular flow rate) to remove mildly air bubbles existing between carbon particles, and be continued for a time period for about one (1) bed volume before increasing the flow rate up to the regular rate. This procedure will minimize the carry over of carbon particles entrained by air bubbles.

C) Backwashing in BAC Filter

Excessive biological growth leads to the growth of higher organisms in BAC filters. In addition the presence of microorganisms and higher forms of life in BAC filters leads to more rapid pressure buildups and requires more frequent and efficient backwashing procedure. The effect is more drastic in warm water than in cold water. It is so hard to backwash out such higher forms of life from BAC filters. BAC filters must be backwashed on a regular basis to prevent the proliferation of higher organisms in the media and maintain a low trophic level.

D) Appendix: Background Information on Backwashing

D-1) Granulometry

In general, the smaller the activated carbon granule, the better the adsorption performance due to kinetics. However if a granule becomes too small, hydraulic problems will be encountered with resulting high pressure drop. In addition, as a carbon granule size becomes very small, it becomes difficult to reactivate.

Mesh size - The granulometry is determined by sieving a sample of GAC. The sieve sizes are based on the US Mesh system, where the number refers to the openings per inch. This means the higher the sieve number, the smaller the grain size.

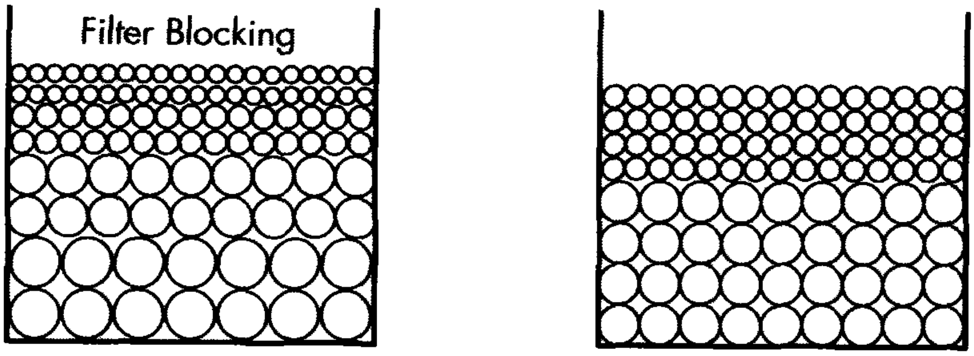
The sieve sizes between which most of the GAC is retained are often used to describe the carbon. The **CALGON Carbon Filtrasorb®** range comes in five main sizes; 12 x 40; 8 x 30; 8 x 16; 8 x 20 and 10 x 20.

Effective Size - The effective size is the diameter for which 10 % by weight of granules are smaller. It is an indicator of the filtration and pressure drop performance of the GAC. A lower effective size will have a higher pressure drop and filter smaller particles from the influent water.

Uniformity Coefficient - This is an indicator of the range of the grain size. The lower the uniformity coefficient, the more uniform the medium as illustrated in Figure 1. A uniformity coefficient of 1 (one) indicates all the granules have the same size. Most GAC used in drinking water treatment such as **Filtrasorb® 300**, which is a 8 x 30 US Mesh and **Filtrasorb® 400**, which is a 12 x 40 US Mesh have a uniformity coefficient of 1.7 to 2.1. **Filtrasorb® 816, 820, TL820** and **TL830** have a low uniformity coefficient of 1.4 to 1.5 and have been specially designed for sand filter conversion, where in-depth filtration is obtained. This allows the frequency of backwashing for filter cleaning to be greatly reduced. The uniformity coefficient of 1.4 to 1.5 still ensures segregation of the bed so the adsorption front is maintained after backwashing which maximizes the adsorption capacity.

	Iodine Number minimum	**Density** backwashed & drained	**Mesh Size**		**Effective Size** typical	**Uniformity Coefficient** typical
	mg/g	kg/m^3	US Mesh	mm	mm	-
Filtrasorb® 100	850	500	8 x 30	2.36-0.60	0.85	1.9
Filtrasorb® 200	850	500	12 x 40	1.70-0.425	0.65	1.7
Filtrasorb® 300	900	460	8 x 30	2.36-0.60	0.85	1.9
Filtrasorb® 400	1000	440	12 x 40	1.70-0.425	0.65	1.7
Filtrasorb® 816	900	485	8 x 16	2.36–1.18	1.4	1.4
Filtrasorb® 820	900	480	8 x 20	2.36–0.85	1.1	1.5
Filtrasorb® TL820	900	500	10 x 20	2.00-0.85	1.0	1.4
Filtrasorb® TL830	1000	460	10 x 20	2.00-0.85	1.0	1.4

Table 1: The **Filtrasorb®** range of granular activated carbons.



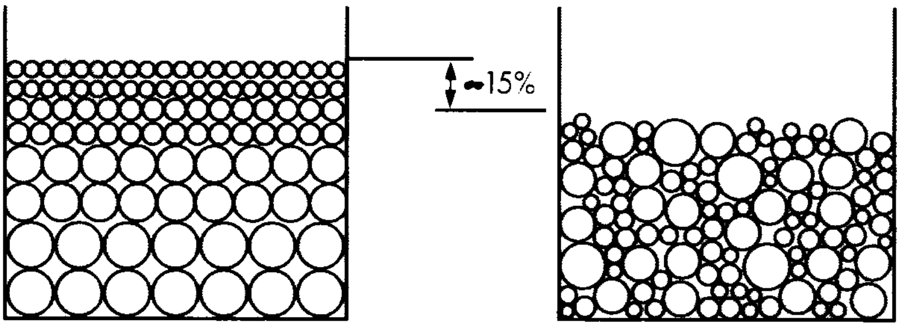
High Uniformity Coefficient Low Uniformity Coefficient

Figure 1: The difference between a high and low uniformity coefficient.

D-2) Backwashed and Drained Density (drinking water / wastewater)

In drinking water/wastewater water, granular activated carbon is backwashed, that is an upward flow of water to remove fine carbon particles and air and to segregate the bed. Segregation is where smaller granules are pushed to the top of the bed while larger granules migrate to the bottom. This results in a lower density typically **85 to 89 %** of the apparent density (AD). This means the height of carbon in an adsorber after filling will increase after the initial backwash. This is illustrated in Figure 2.

The backwashed and drained density is the parameter used for sizing of adsorption equipment and determining the weight of carbon required for drinking water/wastewater applications. When carbon is delivered by volume in bulk tankers for example, the weight of carbon delivered is determined from the segregation factor and the apparent density of the particular batch.



Backwashed and Drained Density. (Segregated) Apparent Density (Settled)

Figure 2: The difference between the Apparent Density and the Backwashed and Drained Density.

Table 2: LV vs. Bed Expansion for Various Carbon Products

Product	FS 400 CAL (12x40)	FS 300 SGL (8x30)	FS 816	FS 820	FS 100	FS 200
Temp (°C)	25 30 35	25 30 35	25 30 35	25 30 35	25 30 35	25 30 35
LV (m/h) at						
10% Exp'n	16 18 20	24 26 29	46 50 55	27 30 32	34 38 41	21 23 25
15% Exp'n	20 21 23	30 33 36	52 58 63	33 36 39	40 44 48	25 28 30
20% Exp'n	22 24 26	34 37 40	58 64 69	37 40 44	46 50 54	29 32 34
25% Exp'n	25 27 29	38 41 44	63 69 75	41 45 48	50 54 58	33 36 38
30% Exp'n	28 30 32	42 45 48	68 74 81	45 49 53	55 59 63	36 39 42

* Note: Above estimated LV values include +/- 10% error depending on the variation of MPD and Apparent Density.