SpinTek Filtration, 10863 Portal Drive, Los Alamitos 90720 USA www.spintek.com

SPINTEK REPORT ON ANTHRACITE/GARNET MEDIA

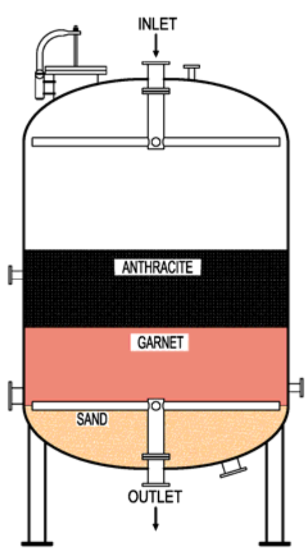
SpinTek Filtration, a leading manufacturer of SX coalescing filters, provides anthracite and garnet to very exacting standards for the worldwide mining industry. The question often asked is, “Why ship garnet or anthracite from the USA and not buy local products?”

While we appreciate a desire to source locally to mine sites suitable products rather than pay shipping prices from the USA, to continue to support our clients with low cost and highest quality products we undertook an extensive investigation of African garnet and anthracite to determine if African-produced media would stand up to SpinTek standards.

As a brief overview the SpinTek filter is crucial to the operation of an SX circuit as it provides entrained organic removal but also acts a filter of solids and crud down to 10 microns. The garnet and the anthracite are essential to both of these functions and the characteristics of each product are special for these specific needs.

The drawing below is a typical SpinTek Dual-Media cutaway showing the top anthracite layer and the lower garnet layer. The anthracite layer can vary in depth depending on plant operation but is typically 18-24” (457-610 mm) and the garnet is in the same depth ranges.

To show relative deminsions the cut away Dual-Media in the drawing shown below has 450 mm of garnet, 4450 mm of anthracite and a freeboard for media expansion of 600 mm.



Dual Media Filter Drawing

The following photo shows a small SX filter system with 1.2 meter diameter filter vessels though much larger vessels with filter diameters of 4.7 meters are not uncommon:

Phelps Dodge Pilot

The photo below is typical of a large installation with flow rates in the 1800 m3/hr range using the SpinTek CoMatrix design using anthracite and garnet as part of the filtration/coalescing process:

Spence Copper, Chile (below)

ANALYSIS OF AFRICAN AND SPINTEK GARNET

Garnet is used in SpinTek filters to remove suspended solids from the aqueous stream, typically electrolyte, and the material provides excellent filtration down to 10 microns and high solids holding capacity in the range of 15 kg/m2 of filter area. Garnet is used in lieu of sand, as the filtering media as particle distribution of garnet is typically much narrower; is more acid resistant than sand; and also has significantly less dust--a serious consideration for operator safety during loading of the filters with media.

The name "garnet" comes from either the Middle English word *gernet* meaning 'dark red', or the Latin *granatus* ("grain"), possibly a reference to the *Punica granatum* ("pomegranate"), a plant with red seeds similar in shape, size, and color to some garnet crystals. (Wikipedia, Feb. 2011). This is why quality garnet brands are called Ruby Red, etc. and the garnets should be very clear in color when held to the light.

The SpinTek garnet is sifted carefully to make a product that has a narrow pore distribution of between US 30 and 40 mesh (425-600 microns). A garnet layer with an extremely fine pore distribution acts as a filter effectively removing solids from the electrolyte or raffinate stream down to ten microns. When the distribution of garnet particles varies, this adversely affects the ability of the garnet to remove smaller suspended solids.

It can be very difficult to prevent garnet particles from being broken up during the filter service or regeneration steps. The air scour step in particular is very hard on the filter media; however, the SpinTek garnet is designed to hold up to these vigorous operating conditions.

Not only is SpinTek garnet low in dust which can be a serious hazard to operators during loading, but garnet containing dust particles can also cause high pressure drops in the filters due to poor service and backwash distribution. Since garnet is very acid resistant, more so than sand, it is naturally the preferred media material in SpinTek filters.

The photo below shows typical SpinTek Ruby Red garnet. Note that not only is the color sharp but free of impurities. Impurities can break up easier than hard garnet causing fines and high pressure drops and even the plugging of the air scour or outlet wedge wire or wire mesh. It is crucial to avoid impurities as they are easily crushed, causing fines that plug wire screen or wedge wire internals and also cause high pressure drops across the entire filter bed.

SpinTek Garnet

SpinTek does not purchase just any grade that a supplier happens to have available. Our garnet is manufactured and sieved to our exacting specifications and all SpinTek media products come with certificates of conformity. We are especially concerned with small “fines” that can cause plugging of laterals and radials and also cause high pressure drops when operating the filters. We have had an additional sieve added to the standard garnet sifting tower to insure our product meets specification.

Note the very sharp cut off and size distribution of SpinTek garnet in the Size Analysis Chart below. This is a typical Certificate of Conformity form supplied with every SpinTek shipment.

	SIZE ANALYSIS				
DATE:	1/29/2010				
GRADE:	Ruby 36#				
ASTME	SIEVE	WEIGHT	% WEIGHT	CUM. %	WEIGHT
MESH	MICRON	RETAINED	RETAINED	RETAINED	PASSING
10		0.00	0.00	0.00	100
20	850	285.30	57.06	57.06	100
30	600	170.20	34.04	91.10	99.81
40	425	44.30	8.86	99.96	65.98
50	300	0.20	0.04	100.00	2.54
60	250	0.00	0.00	100.00	0.00
Pan	-250	0.00	0.00	100.00	0.00
	Total =	500.00			
D10 % =850µ 12#					
D40 % =596µ 17#			Effective Size =608µ 30#		
D60 % =828µ 21#					
D90 % =608µ 30#					
			Uniformity Coefficient =1.03		

SpinTek Garnet Size Analysis Chart

The material captured by the US 50 mesh screen must be below 1.5% and 100% retention on any smaller screens. As seen in the above Size Analysis Chart, the SpinTek garnet has a 0.04% garnet retention on the 50 mesh screen.

AFRICAN GARNET

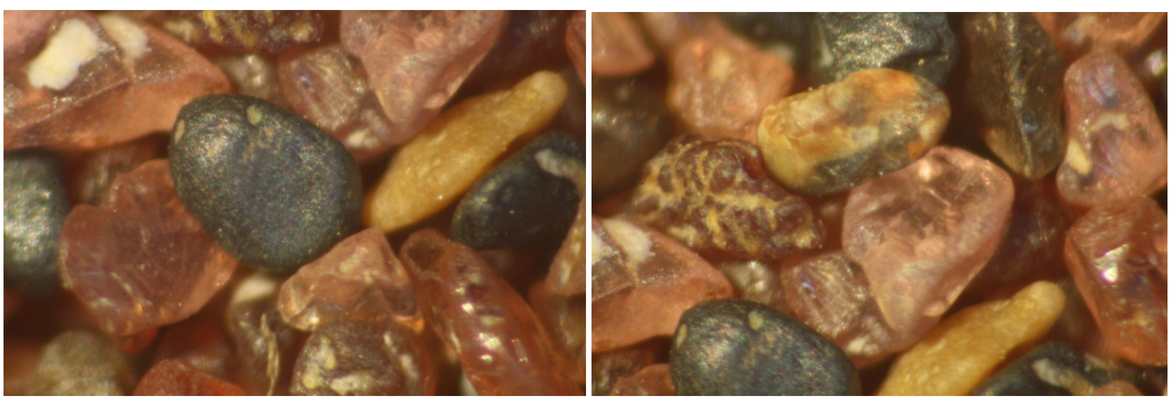
SpinTek obtained garnet samples from several sources currently supplying the African SX mining industry. The goal was to find a local supplier who met our specifications or one we could work with to raise their product to our standards. The product most prevalent on the continent is referred to as “Africa Pegmatite Garnet”.

A sample of this material was obtained and photographs of the material are shown below. As can be seen in the three photographs below, this is not truly garnet but a mixture of various materials with various shapes and sizes.

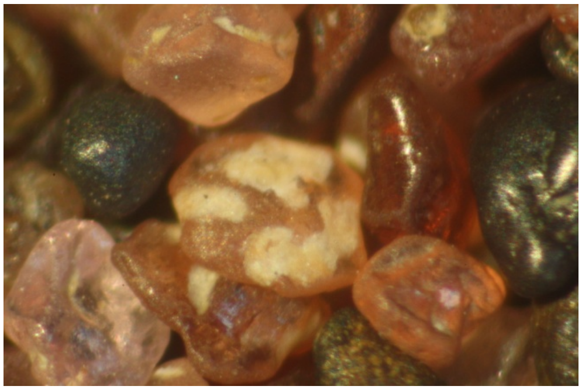
The material shown below was tested and was found to have a good deal of ilmenite mixed in with the garnet. This is the black material that is shown in the photographs. Ilmenite is a very brittle mineral that is used for manufacturing paints and various metal products. It breaks down very easily and creates a black powder dust. When this dust is mixed with water it can cause staining on stainless and aluminium parts. While we do not know this for certain there is strong evidence that causes us to believe this “garnet” is actually the waste product from an ilmenite mine in Africa.

There also seems to be a calcium build up on the garnet particles. This is the white chalky material shown in the pictures below. This calcium will slowly knock off as the particles rub together and create a white dust that will be seen in the electrolyte and in the air as dust particles when the garnet is being loaded into the filters.

The material when used in a SX filter will not provide filtration in the ten micron range as we specify, will create fines that lead to high pressure drops, and as it is easily crushed, will break apart blinding the filter flow distribution systems.



African Garnet showing ilmenite



African Garnet showing calcium

Below is the analysis of the sample shown above and it obviously does not meet the requirements of a SX filter:

DATE: 2/22/2011

GRADE: AFRICA PEGMATITE GARNET

ASTME MESH	SIEVE MICRON	WEIGHT RETAINED	% WEIGHT RETAINED	CUM. % RETAINED	WEIGHT PASSING
10		0.00	0.00	0.00	100
20	850	0.00	0.00	0.00	100
30	600	0.19	0.19	0.19	99.81
40	425	33.75	33.83	34.02	65.98
50	300	63.29	63.44	97.46	2.54
60	250	2.53	2.54	100.00	0.00
Pan	-250	0.00	0.00	100.00	0.00
	Total =	99.76			

D10 % =549µ 33#

D40 % =413µ 41#

D60 % =374µ 44#

D90 % =315µ 49#

D40 % =413µ 41#

D90 % =315µ 49#

Effective Size =315µ 49#

Uniformity Coefficient =1.47

Based upon a requirement of 40 mesh (425 microns) being the finer of the screens that 63.29% pass through the 40 mesh screen and even 2.53% passed through even a 50 mesh screen (300 microns).

This sieve analysis was performed on “new” and unused sample. Once this material is actually put into service the ilumenite and other contaminants will break down to fines making this particle analysis even worse.

Using the brand new material for analysis this is how this material would work in a SX dual-media filter.

The following chart shows what a significant impact this African garnet has on a typical filter designed for operation at 215 m3/hr. The chart shows that the material sold as garnet for a filter this size has 5.3 m3 of the 8.0 m3 garnet is out of specification. This represents 12,274 kg of fine material that is over 40 microns in size but note the very small fines of 474 kg captured by a 250 micron screen. Again, this is material that is fragile and even greater fines will be generated immediately upon putting the filter into service.

Typical Operating Conditions		**SpinTek Model SX-1115**			
Flow Rate per Filter		215	m3/hr	945	gpm
Diameter of Filter		4724	mm	15.5	feet
Area of Filter		17.5	m3	189	sq feet
Flow Velocity through Filter		12.3	m3/m2	5.0	gpm/ft2
Bed Depth of Garnet		457.2	mm	18	inches
Volume of Garnet in Filter		8.0	m3	282.9	ft3
Density of SpinTek garnet		2327	kg/m3	145.0	lb/ft3
Total Weight of garnet in Filter		18645.3		41,020	
Screen Size		425	microns	40	US Mesh
% Captured by Screen		33.8%		33.8%	
Volume of garnet retained		2.7	m3	63.7	ft3
Weight of garnet retained		4195	kg	9,229	lb
Screen Size		300	microns	50	US Mesh
% captured by 50 mesh screen		63.3%		63.3%	
Volume of garnet retained		5.1	m3	179.0	ft3
Weight of garnet retained		11801	kg	25,961	lb
Screen Size		250	microns	60	US Mesh
% captured by 60 mesh screen		2.5%		2.5%	
Volume of garnet retained		0.2	m3	7.2	ft3
Weight of garnet retained		474	kg	1,042	lb
Total Material that can pass through outlet wedge wire screens					
		5.3	m3	186.2	ft3
		12274	kg	27,003	lb

Chart Showing out of specification African Garnet

CONCLUSIONS- SpinTek Garnet vs. Africa Garnet

The cost of dual-media filters are relatively expensive and certainly crucial pieces of equipment to the modern SX-EW operation. Often these filters are compromised by the use of replacement media that is off specification though appears to be a low cost compared to SpinTek provided media. Through the analysis of the African supplied product versus the SpinTek product that requires importation, hence higher shipping costs, is truly insignificant compared to the performance benefits. We were disappointed but our conclusions are very clear that this locally supplied product is not up to specification and even by further processing cannot be brought up.

It is shown that the African product is full of contaminants and even worse the garnet is very brittle which causes a myriad of filter malfunctions. A summary of the effects are listed below:

1. High brittleness leads to loss of “garnet” and hence replacement is much more frequent.
2. Brittle garnet generates “fines” that can clog the upper or lower distribution system and air distribution leading to high pressure drops and reduced service flows.
3. Fines, lighter than full size garnet particles can migrate into the upper anthracite bed and cause flow distribution problems which lead to shorter service runs and higher organic entrainment in the rich electrolyte.
4. The garnet can also shed calcium and other elements/compounds that will enter the SX electrolyte stream.

Our conclusion is that the use of this material will very quickly adversely affect the operation of SX Dual-Media filter.

ANALYSIS OF AFRICAN AND SPINTEK ANTHRACITE

While garnet is very crucial for filtration of aqueous hydromet streams the use of anthracite is equally important as both a prefilter for the garnet and as a coalescer of organic. Anthracite is a hard, coal based product and the removal of organic is due to the anthracite's affinity for organic. Organic will first coat the surface of the anthracite and then further coalescing will occur as other organic fine droplets "touch" the organic coated anthracite, form larger organic droplets and are removed from the aqueous stream.

Much of the organic removed by the anthracite will be caught within the matrix of the entire bed of anthracite though some larger droplets of organics can be formed. These larger droplets can break free from the anthracite and float to the top of the filter to be discharged as almost 100% organic.

These two removal methods of organic 1) collection within the bed and 2) coalescing to large droplet size are dependent on the anthracite meeting the specifications required for this type of hydromet service. The anthracite must be of narrow particle size distribution and also physically hard and durable to prevent premature breakdown of the anthracite resulting in loss of anthracite, generation of fines, higher filter operating pressures, and poor organic removal capacity.

This report is from SpinTek's evaluation of African anthracite as it's suitability for use in our filters.

The first test we performed was for particle size distribution:

<u>PARTICLE SIZE DISTRIBUTION</u>

The particle size distribution of the anthracite is crucial as it effects:

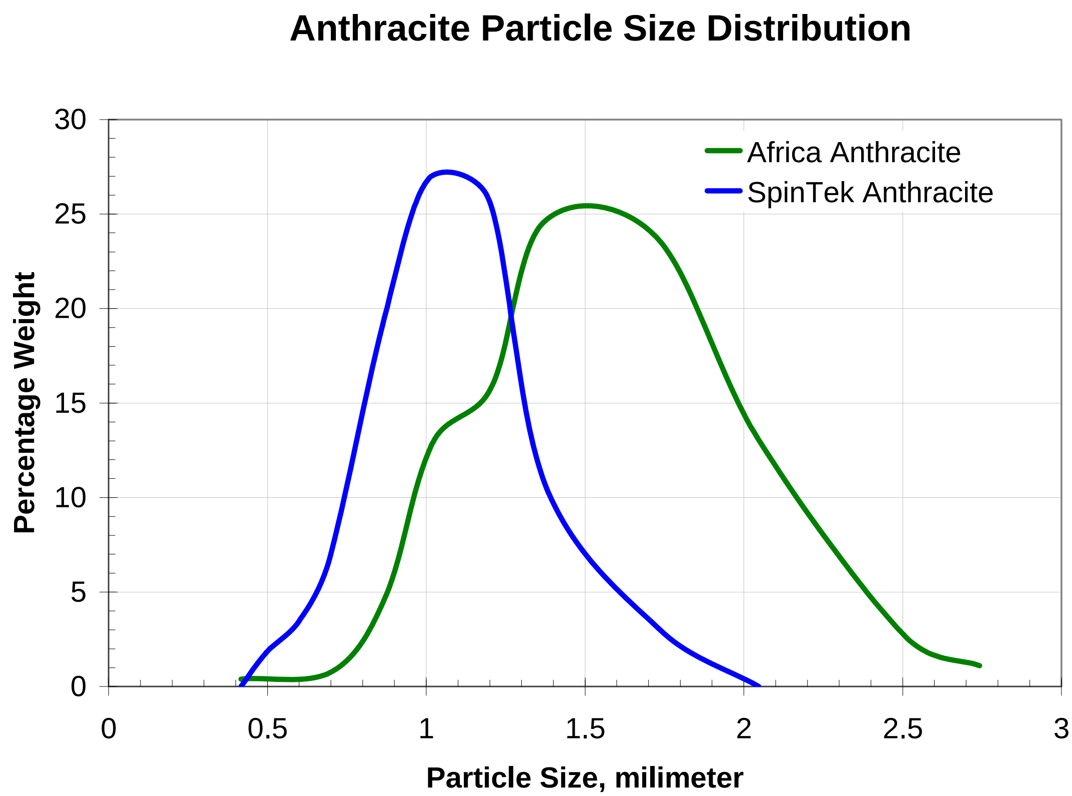
1. Filtration efficiency
2. Backwash effectiveness
3. Even fluid flow through the bed

Listed below is the SpinTek Standard for anthracite.

Mesh	0.8-0.9 mm
Effective Size	0.8-0.9 mm
Range	0.5-1.2 mm
Uniformity coefficient	1.7
Density	859 kg/m3 (58 lb/ ft^3)

Filtration efficiency as well as coalescing ability requires anthracite with a narrow particle size distribution. If the particles are of varying sizes this will cause low/high pressure drops within the bed causing fluid channelling resulting in lower filtration and coalescing efficiency.

The chart below is the particle size distribution of the SpinTek anthracite and the locally supplied Africa anthracite. Note that not only does the SpinTek product have a very narrow size distribution but also that the size of the particles is smaller and in the preferred range of 0.8-09 mm range.



The varying distribution and particle size of the African Anthracite versus the tight distribution and particle sizing of the SpinTek Anthracite can be easily seen in the visual below:

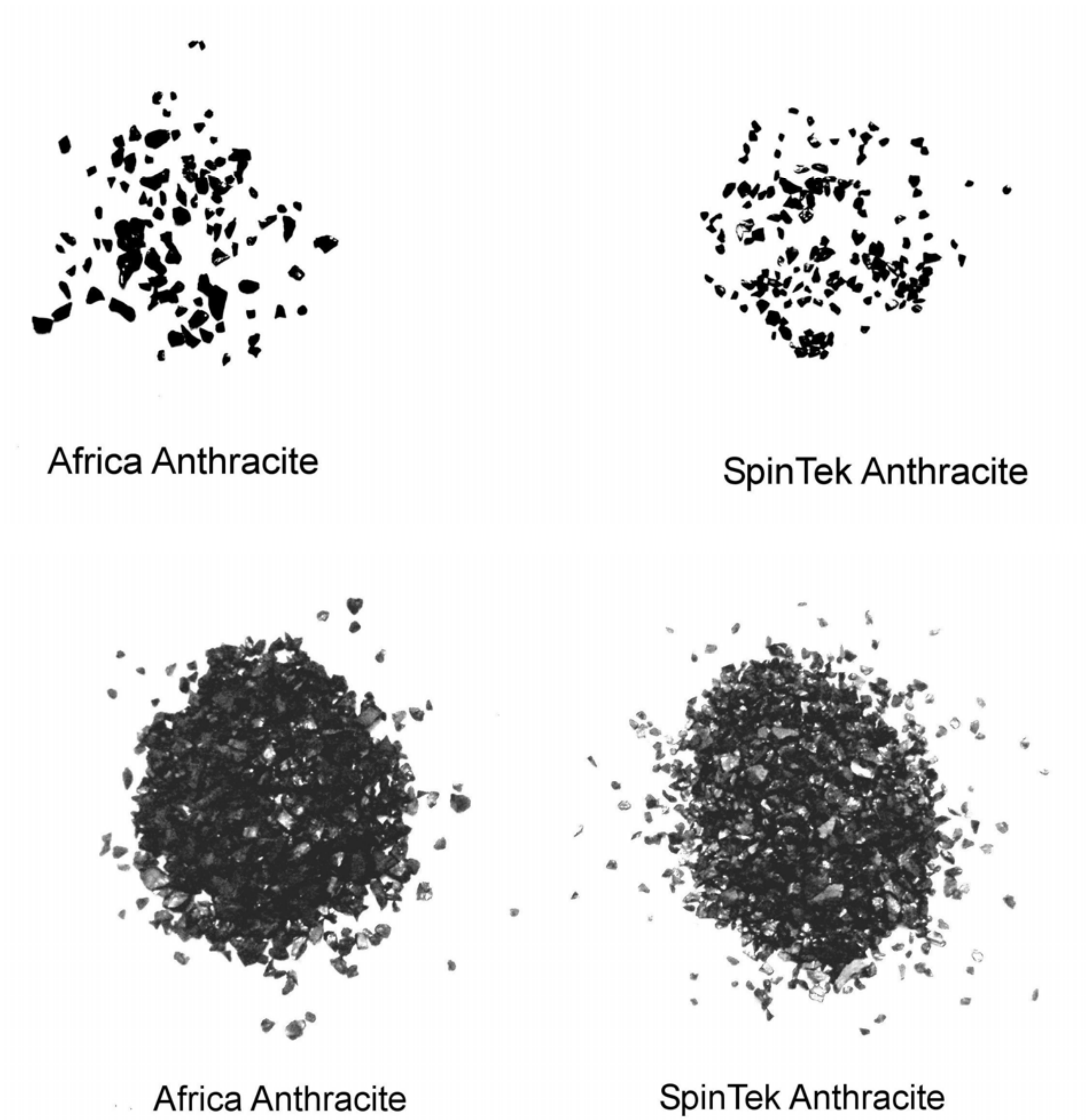


Photo Magnification Showing tight distribution and particle size of SpinTek Anthracite

BACKWASH EFFICIENCY - Anthracite

A hydromet dual-media or CoMatrix filter uses pressurized air upflow through first the garnet bed and then the anthracite bed to scrub the media of accumulated organic and solids. Narrow particle distribution ensures even distribution and proper scrubbing whereas anthracite with a wide particle distribution will have preferential air flow through the media bed which results in not cleaning the entire bed.

After air scour the bed is expanded so that the organic and the anthracite “fines” can be flushed from the system. An indication of the effectiveness of backwashing is to look at “bed expansion”. Bed expansion is how much the media expands to allow solids and organic to flush out.

An anthracite bed, as an example, that is 450 mm deep if expanded to 600 mm during backwashing is considered.

(600/450) – 1 = 33% expanded

Ideally the anthracite bed expansion should be 10-15 % or greater.

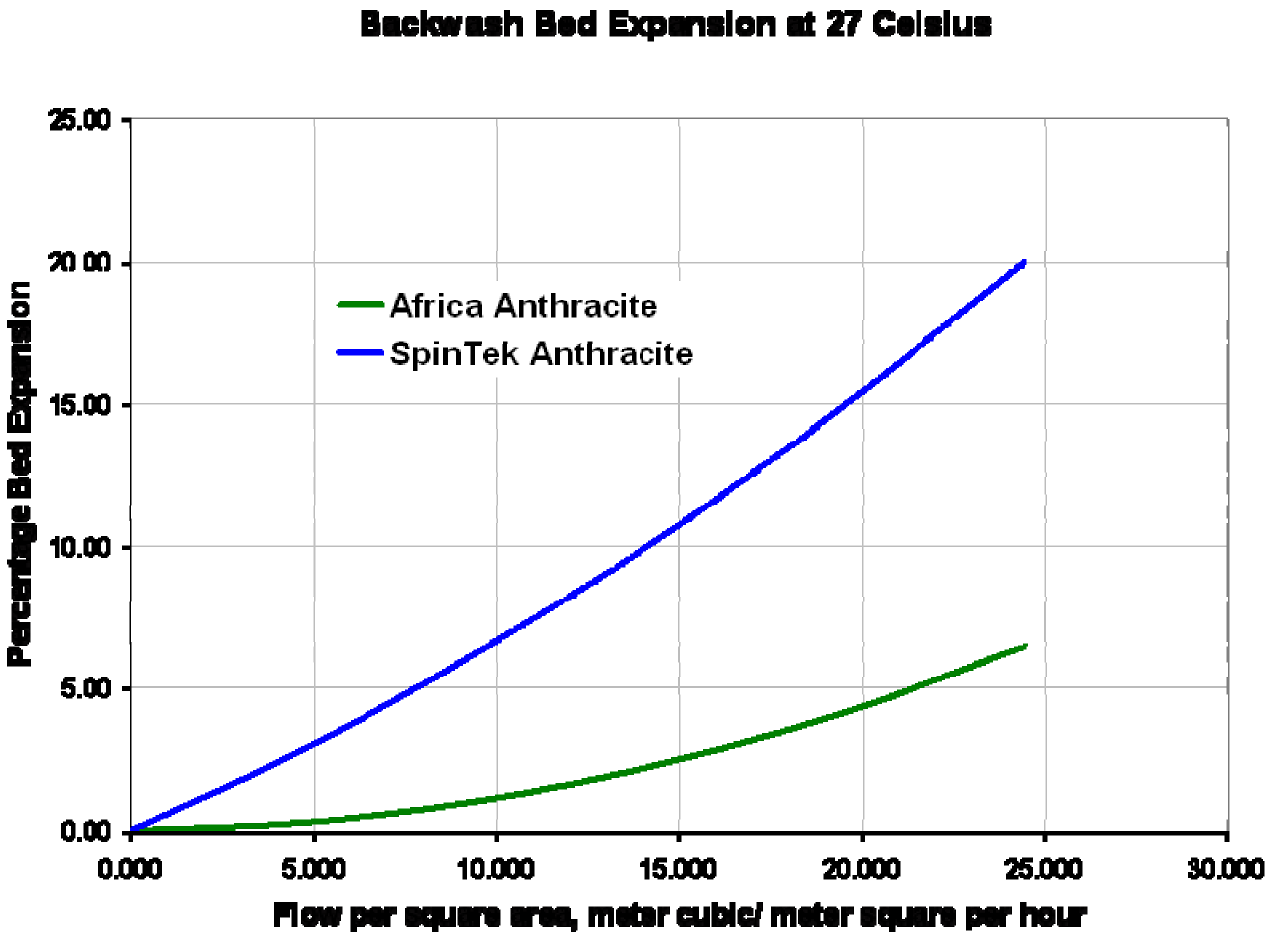
Expansion of the bed is affected by the velocity of the backwash fluid. The typical velocity value of backwash fluid is 8 gpm/ft2 (19.6 m3-hr/m2) but can vary from plant to plant.

The range is shown below:

2	gpm/ft2		4.9	m3-hr/m2
4	gpm/ft2		9.8	m3-hr/m2
6	gpm/ft2		14.7	m3-hr/m2
8	gpm/ft2		19.6	m3-hr/m2
10	gpm/ft2		24.5	m3-hr/m2

The backwash rates and bed expansion though are based upon anthracite with particle sizes of 08.-0.9 mm. The larger the anthracite particle size the lower the bed expansion and the less efficient the cleaning.

As shown in the chart below, based upon these typical backwash velocities it is important to evaluate the bed expansion obtained by the SpinTek anthracite versus the Africa supplied product:

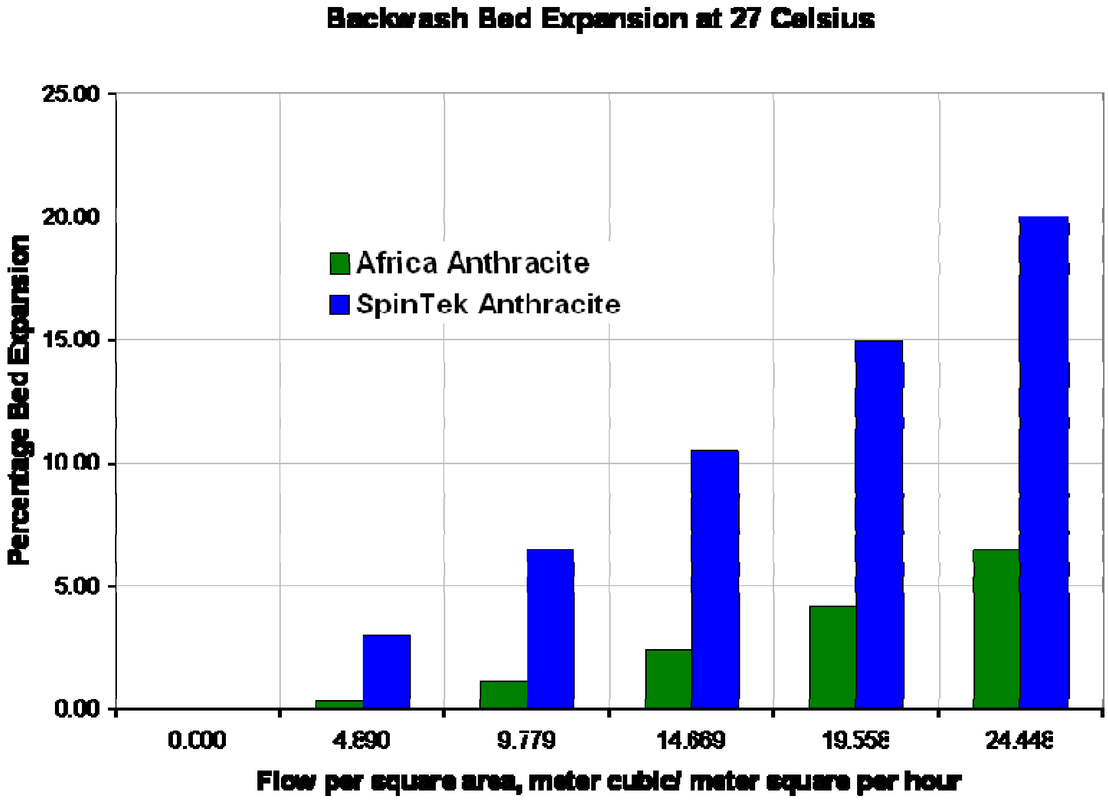


As can be seen the SpinTek anthracite meets the 15% expansion when the filter is backwashed at 20 m3/hr-m2 whereas the Africa anthracite never meets the targeted backwash value.

Note that the Africa anthracite chart assumes a very narrow size distribution which has been shown to not be true hence even less bed expansion is to be expected. Due to significantly larger particles, the Africa anthracite curve would fluctuate downward even more than shown.

Temperature has an effect on the amount of expansion and 30C has been used as a typical backwash value. Bed expansion increases with increasing temperature but the relative differences between the two anthracites would stay relative to each other.

The chart below shows the expansion value for the SpinTek and Africa anthracites at various flow rates.



HARDNESS VALUES

Hardness of the anthracite is extremely important for proper filter operation, maintenance, and operating costs. Anthracite that is brittle will break up easier under the severe air scouring of the bed forming small anthracite fines. These fines result in loss of good anthracite but can also lead to high pressure drops, excessive anthracite consumption, and high filter pressure drops.

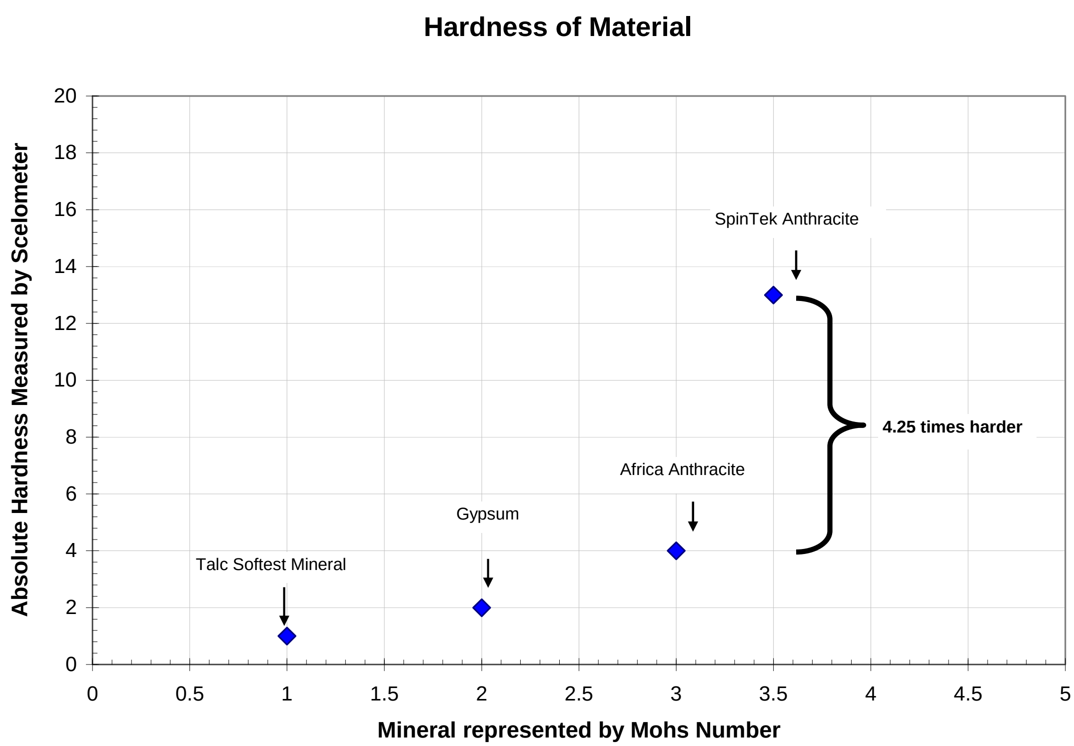
The problem of anthracite brittleness is compounded if the size of the anthracite is off specification (larger than specified) and actual bed expansion from backwashing is low. High fine generation with low backwash expansion results in poor organic removal, shorter service runs, and high filter pressure drops.

A common measurement of hardness is the Mohs test and the result of independent laboratory testing is as follows:

SpinTek Anthracite: 3.5
African Anthracite: 3.0

“Different methods are the base for hardness tests of minerals. Commonly used and internationally known is the Mohs (mineralogist, 1773-1839) hardness scale. It depends on the discovery that softer substances scratch harder ones. So Mohs created his scale, arranging 10 minerals according to their scratching hardness from the softest material (talcum) with hardness 1 up to the hardest material (diamond) with hardness 10. The Mohs scale is a relative scale.” (Definition of Mohs Test Wikipedia.)

The Mohs test is an indication of hardness for geological applications but translated into “relative values” is shown in the chart shown below. The difference between 3.0 and 3.5 is also equal to the hardness difference between pure copper (3.0) and bronze (3.5).

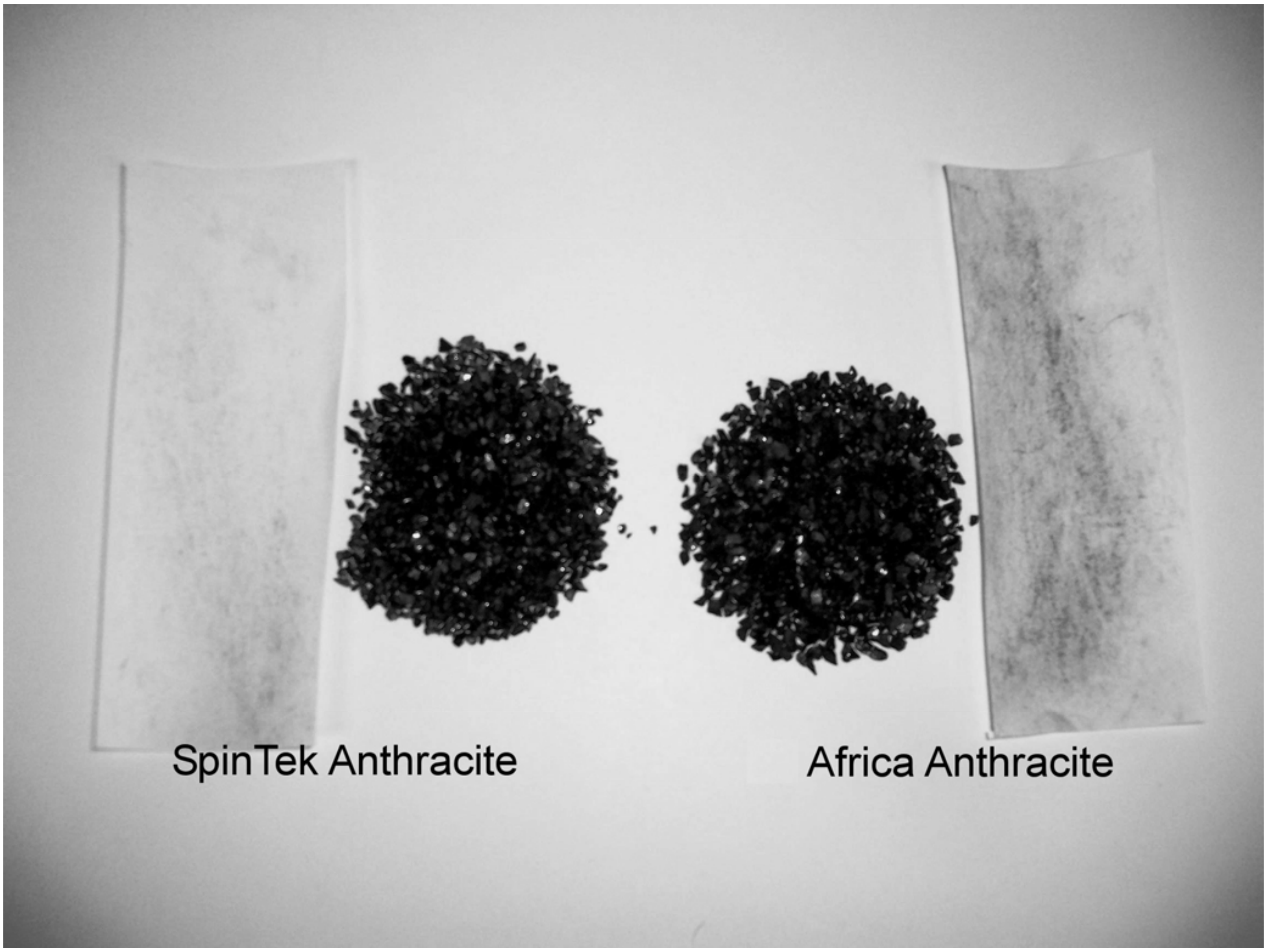


The hardness is important as the harder the anthracite is the less fines and better flow distribution that will be obtained.

To demonstrate the difference in hardness a “grinder test” was set up to allow for a more analytical as well as visual indicator of the two materials.

The Grind Test was performed on 3.00 gram of each Africa Anthracite and SpinTek Anthracite. To perform the test a filter paper is rolled into a tube and placed in a glass bottle. The anthracite is then added and a few ball bearings are added to provide a grinding surface. The bottles were sealed and then rocked back and forth automatically on a shaker table for only one hour.

The following photo shows the obvious weakness of the African anthracite compared to the SpinTek standard.



Shaker-Grinding Test

The shaker test provides a relative determination of the hardness of the two anthracites as the anthracite is rubbed together like would be experienced during backwashing. Note, however, that air scouring of the anthracite is much more vigorous than this simple shaker test so the relative difference in hardness is even more significantly apparent in actual plant operation.

While the visual discoloration of the filter paper is interesting in the Shaker-Grinding Test above, the weight loss comparison shown below in the Mass Loss Test quantifies percentage of mass loss and the striking difference in materials.

Mass Loss due to grind test

GRIND TEST	INITIAL MASS OF ANTHRACITE	FINAL MASS OF ANTHACITE	PERCENTAGE MASS LOSS
African Anthracite	3.00 gram	2.57 gram	14.3
SpinTek Anthracite	3.00 gram	2.84 gram	5.3

CONCLUSIONS – SpinTek Anthracite vs. Africa Anthracite

1. Particle size distribution is much narrower with the SpinTek product providing more consistent filtration and coalescing.
2. The wide and large particle distribution of the Africa supplied anthracite will result in poor backwashing.
3. Mohs Hardness values represent the ability of a material to resist scratching and the SpinTek product is much harder than the Africa sourced anthracite.

The organic loading of anthracite is greatly influenced by the particle distribution of the anthracite which, if uniform, will provide a slow even flow through the bed. When calculating the surface area of a bed of anthracite the SpinTek material has approximately 10% greater surface area than the African supplied material. This small difference is at first surprising but closer examination of the particle distribution curves shows the African material has so many "fines" that create a large surface area but are near ineffective in actual operation. The higher fines do not add to the anthracite capacity of the African material but have the added negative effect of increasing pressure drop through the bed and causing an irregular flow path. The accumulated effects of the differences produce an additional 10% organic loading capacity of the SpinTek anthracite.

FINAL CONCLUSIONS

Part of the SpinTek Mission is to maintain low costs without sacrificing quality. It is beneficial to the Company to be cost competitive in the marketplace and to pass along those savings to our customers. While it is especially desirable to reduce cost for spare parts, including media, the apparent "cost reduction" must be compared to the performance impact on the dual-media filters for final polishing of the electrolyte prior to electrowinning. Insomuch as we have examined carefully the differences between the garnet and anthracite from Africa compared to SpinTek products, the obvious differences have been presented clearly in this paper.

Dual-Media filters are a relatively expensive yet critical part of the modern SX operation; thus, in an attempt to procure cost competitive media, SpinTek Engineering undertook a 6-month study to find alternate suppliers of Garnet and Anthracite. All samples were examined and rigorously tested but none of the suppliers was able to provide media that stood up to our requirements. Although our engineers were unsuccessful in finding suitable alternate suppliers, they ultimately proved SpinTek's higher quality of media. Mined and processed to our exacting specifications, the customer receives a superior product with lasting performance that holds up under extremely rigorous mining conditions and prevents costly plant shut-downs.

As was shown with both garnet and anthracite testing, the SpinTek grades are far superior from a point of particle size distribution, hardness, lack of contaminants and other important factors. The SpinTek specified anthracite and garnet generate very low levels of fines that can negatively impact flow distribution, filtration quality and coalescing ability.

With over 20 years of experience specific to SX-EW operations, the SpinTek media products are proven to be superior in all aspects of our filtration/coalescing capability.