PICAGOLD®/GoldSorb® Carbon Selection Guide for CIP/CIL Processes

The importance of Activated Carbon in any gold extraction process cannot be over emphasized. Activated Carbon plays a critical role towards the profitability (operating costs) of a gold project and the following factors are considered in choosing the right carbon:

- Hardness & Abrasion Resistance
- Gold Adsorption Kinetic
- Gold Loading Capacity
- Carbon Management

These points are discussed below, and we introduce our PICAGOLD® and GOLDSORB® grades alongside a synthetic selection guide.

Abrasion Resistance

Carbon in a Carbon in Pulp / Carbon in Leach circuit is subject to vigorous agitation, leading to abrasion and inevitably, the production of carbon fines. This leads to the loss of gold on the escaping carbon fines to the tailings dam and as carbon is lost, more carbon is required to replenish the total carbon inventory. While the carbon can be replaced, the gold is lost forever! This affects the production cost of gold, and it is directly attributable to the carbon selected for this function.

In the manufacturing process of Activated Carbon, the activity level of the carbon and the resulting hardness of the product must be carefully monitored and controlled. This is achieved through:

- The activation process, where the purpose is to distribute evenly the pores all throughout the granule
- The post treatment of the carbon, which consists in mechanical abrasion, screening and dedusting in order to obtain a granule which is as resistance to abrasion as possible

Flash activation techniques and the inability to regulate the exothermic reaction in the kiln, by some manufacturers merely lead to most of the porosity at the outside (surface) of the carbon.

The resulting product has good initial activity level / kinetics, but it diminishes rapidly, as the granules are abraded, resulting in poor subsequent adsorption. Furthermore, the granules are weak and generate attrition and fines production all along their life in the circuit, to the point that they eventually all turn into fines.

Jacobi Carbons have developed manufacturing process dedicated to the PICAGOLD® and GoldSorb® grades, making them the most mechanically resistant carbon available.
The industry standard for the carbon mechanical resistance is the ASTM Ball Pan hardness. Whilst this value provides a quantitative measure of the apparent hardness of the carbon, it makes no allowance for the liquid / slurry phase characteristics of the gold processing circuit. The wet attrition methods developed by AARL is thus a more accurate measurement of the carbon's strength, but the most representative and useful indicator of is the actual carbon losses in the circuit... PICAGOLD® has a very low value, with losses usually up to 50% lower than other competitors' products available in the market.

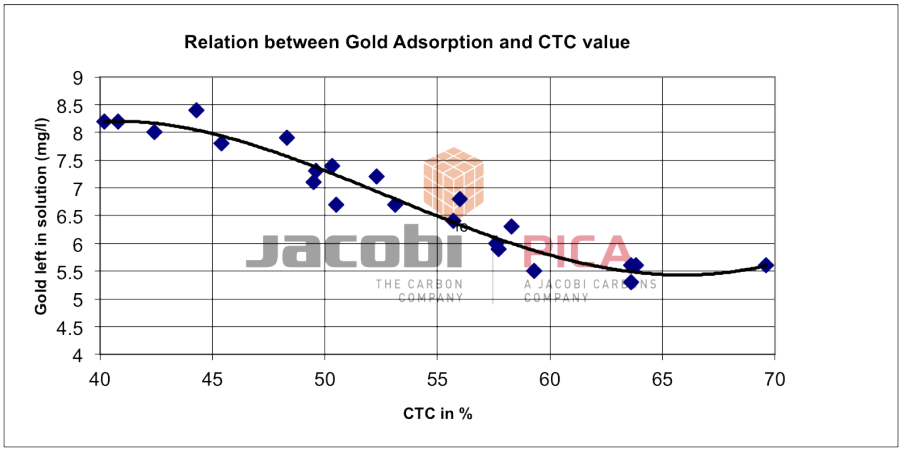
Guidance

In our experience, a rule of thumb on PICAGOLD® G210 AS is: Abrasion Losses ~ 10 –15 gm G.A.C./tonne ore or <0.2% of carbon/strip (this however is an indicative value, which obviously depends on the ore characteristics)

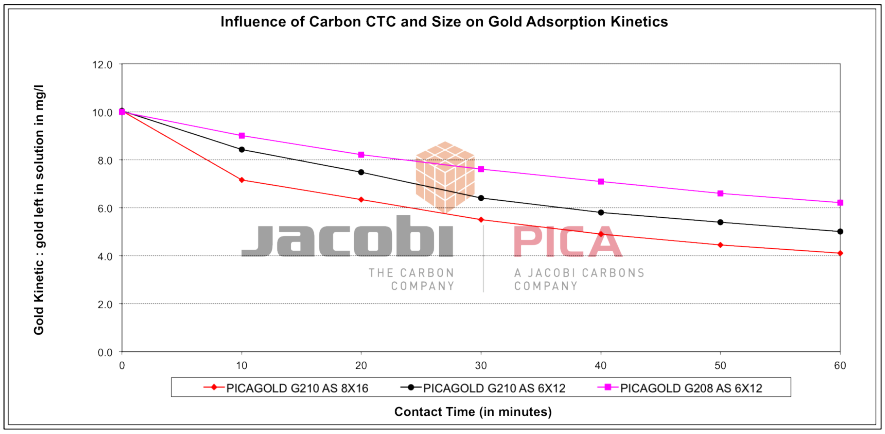
Gold Adsorption Kinetics

This is a measure of the speed of gold adsorption by the carbon, which is the key in the CIP/CIL circuit. A standard measure of the kinetic is the AARL method CA68 that nominates an R value after 1-hour contact time. An R value >55% is recommended and this can only be achieved with premium activity carbon. An alternative method that we uses simulates an adsorption tank, by placing a small quantity of carbon into a beaker of gold solution and recording the reduction in gold at 10-minute intervals over a 1-hour period. This was designed as being the most realistic simulation of a CIP/CIL circuit.

Kinetic is a function of the degree of activation of the carbon, but it is a delicate compromise to find, since the higher the activity (CTC value) the lower the hardness of the carbon (the carbon has more pores and is thus necessarily lighter and weaker). The graph below shows that an optimum is found for a CTC of around 60.



Gold adsorption kinetics are also a function of the size – a smaller carbon has a larger surface area and thus adsorbs gold faster. The graph below shows a comparison between PICAGOLD® G208 AS 6x12, a medium activity G.A.C, with PICAGOLD® G210AS 6x12, a Premium grade, and the same grade in a smaller size, 8x16.

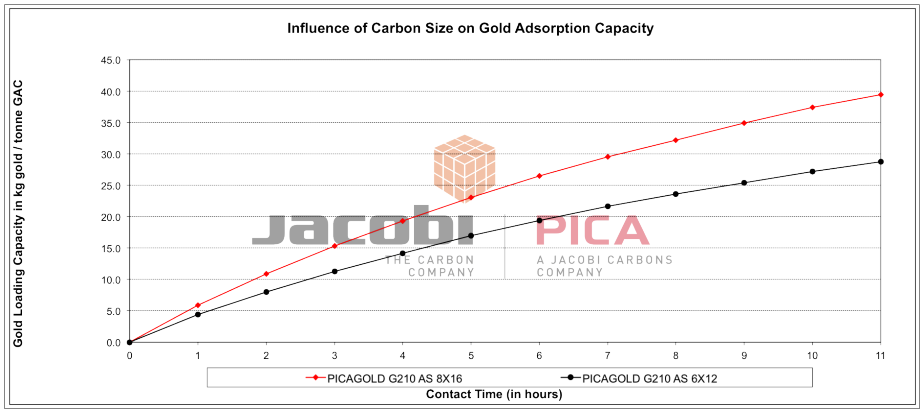


Gold Loading Capacity

Complementary to the gold kinetics, the ability of the carbon to continue adsorbing gold is the very essence of the CIP/CIL process. This loading capacity is dependent on the number of adsorption sites that a carbon possesses, i.e. the activity of a carbon.
The commonly accepted index of Loading Capacity is the AARL K value. It therefore stands to reason that a carbon with a lower K value will result in increased soluble gold losses, which will lead the plant to increase the carbon inventory. This implies higher operating costs, since more carbon has to be handled, eluted, washed and regenerated for a similar output of gold recovery.

The companies method of measuring Gold Loading Capacity (to simulate plant conditions) is the use of 1 gm of carbon being transferred successively into 11 beakers with equal 10 ppm gold solutions. The residence time in each beaker is 1 hour. The Gold Loading Capacity is measured by combining the progressive reduction.

The graph below shows the performance of PICAGOLD® G210AS and reveals the influence of the Carbon size, which has also an effect on the capacity itself.



Carbon Management:
A Commitment To Quality & Service

The preceding paragraphs highlight that small variations in the quality of carbon can have a dramatic effect on gold recovery, and hence the profitability of a plant. This however does not apply only to the virgin carbon: as important is as the carbon choice, is the ability to maintain the carbon properties in the long term in the CIP/CIL circuit, where each carbon granule will spend an average one year!

In reality, the most relevant way to assess the quality of a carbon is not by looking at the virgin carbon (indeed, many carbons look the same!) but by looking at the properties of the regenerated carbon after several months of service life.

A premium carbon will maintain its properties and perform almost as well as a virgin carbon, whereas a poor carbon can see its gold adsorption kinetics reduced by half, if it has not yet disappeared into dust!

Therefore, apart from ensuring stringent quality in our manufacturing process, Jacobi Carbons is committed to providing our customers with ongoing service to maintain the quality of the carbon in the circuit. To determine what to do, one must first identify what can go wrong in the circuit.

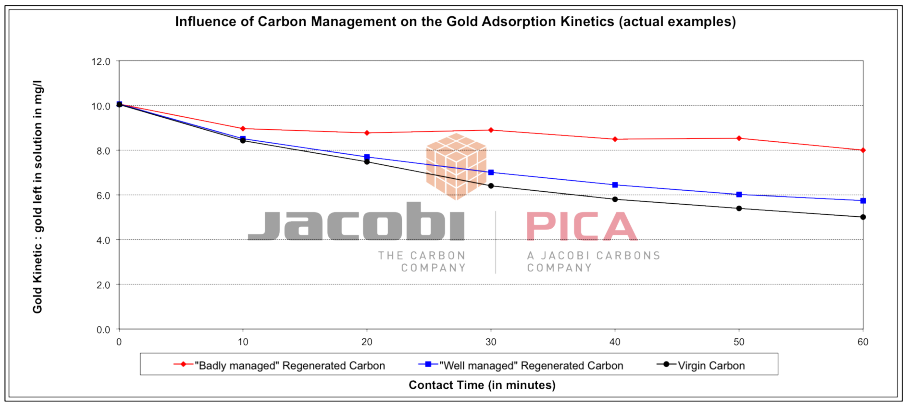
Indeed, the reduction of performance of carbon can have an extremely wide number of causes:

- Contamination/fouling of the carbon by mineral or organic matters present in the ore or brought in by the additives, water or pollutants
- Preg-robbing ore competing with the carbon in adsorbing the gold
- Attrition of the carbon with the propellers, screens and carbon transfer systems
- Poor acid washing efficiency not removing minerals properly from the loaded carbon
- Poor regeneration techniques not removing organics properly
- Extreme temperature changes in the regeneration – quenching stage, leading to breakage of the carbon

Constant monitoring and small modifications to the regeneration kiln's operating parameters (temperature/throughput), acid washing practices and carbon transfer technologies, will generally overcome most of these problems, and restore the carbon to its optimum. However, if these changes go unnoticed, the carbon can deteriorate very quickly, and the wrong remedy will be apply: one will typically add more carbon in the circuit, which will only make things worse!

The below graph shows the gold kinetic performance of a "well managed" and a "badly managed " carbon, in comparison with the virgin carbon. This is taken from 2 real cases, 2 mines using the same virgin carbon, and it must be noticed that there is a bigger gap between the "badly managed" and the "well managed" than between the "well managed" and the virgin. This is how important carbon management is!

Jacobi Carbons's philosophy is to provide a complete technical backup/ support to justify your investment in premium carbon. It is called Carbon Testing and Circuit Auditing services, and it is a joint work between the mine's metallurgist and our carbon experts.



It consists in several stages:

- A circuit survey, based on a site visit and technical questionnaire
- Sample testing (physical, chemical and gold adsorption) by our laboratories
- Analysis and recommendations by our experts on the carbon state and process parameters
- Follow up discussions on corrective actions and possible improvements

We recommend a CTCA to be done every 6 months as a base, and whenever need for troubleshooting. The purpose is precisely to enhance the performance of the gold extraction process and/or to troubleshoot on a specific issue.
Many mines already perform tests on a routine basis: we never pretend to replace the mine's work, but intend to provide an external snapshot of the circuit and carbon status, a useful source of cross-referencing, and above all our experts' analysis and suggestions through the carbon eye.
Our carbon range originates from both the PICA and JACOBI product families, which when the 2 companies merged were found to be very complimentary, offering distinct advantages.

CARBON SELECTION

	GoldSorb			PICAGOLD	
	4500	5500	6000	G208AS	G210AS
K Value (kg/T)	24	28	32	26	30
R Value (%)	45	55	65	50	60
Platelets (%)	7	7	7	4	4
Attrition (%)	2	2	2	1	1

Note: the PICAGOLD® G209, which is widely sold in certain regions, still exists but was found to be very comparable to goldsorb 5500. It was therefore decided to merge these 2 grades into one. Based on the above, the following selection guide is proposed. There is however no absolute rule of selection, and we highly recommend to consult our experts before deciding on the carbon to use.

Technical Bulletin: Carbon Selection Guide

	GOLDSORB			PICAGOLD	
	4500	5500	6000	G208AS	G210AS
It is a first fill	✓			✓	✓
The ore is highly preg-robbing			✓		✓
The ore is low preg-robbing		✓			
An extremely high gold adsorption capacity is needed			✓		
The ore is extremely hard	✓			✓	
The ore contain a high amount of silver, copper, lead or zinc					✓
It is an AAC Pump Cell Circuit				✓	✓
The screen type (especially wedge wire) requires an ultra low platelets count				✓	✓
The gold concentration is very high (>5g/T)			✓		✓
The gold concentration is very low (<1g/T)					✓
The circuit is prone to attrition - Sharp angles and edges in the piping, pumps, agitators				✓	✓

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