By Andy Wilde and Jim Knepper

Application of AquaSorb HS to Condensate Treatment

Within the petrochemicals and power generation industries, it is common practice to recycle condensed steam for use as boiler feed water. Such processes improve plant economics offering a ready source of already heated water (often higher than 80° C), which does not typically require further demineralization by ion exchange. An additional advantage to this recycling of the condensate is that it avoids environmental issues associated with the disposal of contaminated water.

However, when recycled condensates are to be used as boiler feed water for medium or high pressure boilers for process or power generation applications, a down stream ion exchange unit must be installed in order to prevent trace quantities of minerals leached from the activated carbon, thus reducing the efficiency of boilers and turbines.

Additionally, condensate feed waters frequently contain a wide variety of hydrocarbon contaminants that are entrained with the water from process equipment. An example of this would be, leaking seals on rotating equipment such a pump, or from chance contamination by associated hydrocarbon process streams. This hydrocarbon contamination must be removed from boiler feed waters to avoid coking of these contaminants on heating in the boiler, which would produce carbon deposition within the boiler tubes that will reduce heat transfer and overall boiler efficiency. Hydrocarbon concentrations may be in excess of 6 mg/L but are more typically 2–4 mg/L.

In flash boilers and welded water tube boilers, coking occurs on the surfaces where heat flow is highest causing tubes to overheat and distort, or even burst. For boilers using expanded joints, the problem may be worse as the oil quickly penetrates the joint and causing the boiler to leak.

Boiler decoking can be achieved by sand blasting. However, refinery process boilers frequently require more extensive decoking operations requiring the plant to be taken off line and boilers burned out with high temperature oxygen or air. Therefore, keeping the boiler clean of hydrocarbons becomes a major maintenance task.

Condensate typically contains less than 5 mg/L of hydrocarbons. At these concentrations, actived carbon is an extremely efficient adsorption medium for such entrained hydrocarbons and is widely used to treat condensate achieving very high removal efficiencies—frequently greater than 95 percent removal. At concentrations greater than approximately 6 mg/L, carbon retains its effectiveness but additional process equipment may be required (coalescers or pre-filter beds), to prevent premature fouling of the carbon adsorbent by oil droplets.

Extensive research and plant operational experience has shown that Jacobi Carbons AquaSorb HS is a very suitable adsorbent for this application offering hydrocarbon uptakes of approximately 30 weight percent to saturation.

Process Description

This section describes a generic refinery scale condensate de-oiling process. The system described utilizes twin adsorbers removing 2–4 mg/L (saturation level) of dissolved oil from hot condensate at 45° C upstream of an ion exchange resin (IER) treatment bed feeding an 85° C upstream heat exchanger / boiler return loop.

Principal Process parameters were:

- volume flow rate: 50 m^3/h (total)
- carbon filters: 2 x 10.5 m^3 adsorbers in series (21 m^3 total)
- contact time: 2 x 12 minutes (24 minutes total)
- concentration oil:
  - inlet: >2.0 mg/L
  - outlet: <0.18 mg/L
- SiO2 ex GAC: <0.05 mg/L
- SiO2 ex IER: <0.03 mg/L (mean value)

Start-up

1. Following filling of the activated carbon into the adsorber, initial washing is undertaken with hot condensate in down flow at a rate of 2 m^3 condensate/m^3 activated carbon per hour for a period of 72 hours (144 bed volumes of hot condensate). The effluent from the initial washing is discarded to drain.

2. Following this initial washing stage the filter is backwashed in order to classify the bed. The sequence of washing may be summarized as below:

- 30 minutes of backwashing at a bed expansion or 30 percent;
- 20 minutes of backwashing at a bed expansion or 20 percent;
- 5 minutes of backwashing at a bed expansion or 15 percent; and
- 5 minutes of backwashing at a bed expansion or 10 percent.

Operation

After completing the backwashing cycle, filtration in the down flow direction starts. Optimum process flow rate should be controlled to maintain design contact time and the silica content of the effluent water should be determined.

If the initial silica measurements in the effluent water do not comply with the plant operational requirements, additional washing with hot condensate (in down flow), at a rate of 2m^3 condensate per m^3 activated carbon per hour for a further period of 48 hours (96 bed volumes of hot condensate) must be undertaken. The effluent from the second washing should then be discarded to drain. Backwashing is then repeated as detailed in point 2 (above).

Should filter head loss become excessive adsorbers may be backwashed to 30 percent expansion as in 2.

Operational Issues

Principal operational issues typically concern hydrocarbon loads and silica leach from the activated carbon.

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Figure 1: Silica in Condensate After Carbon Treatment

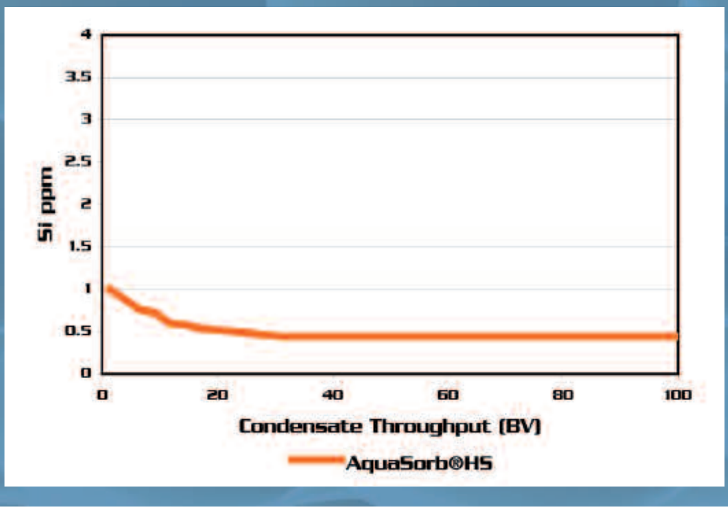
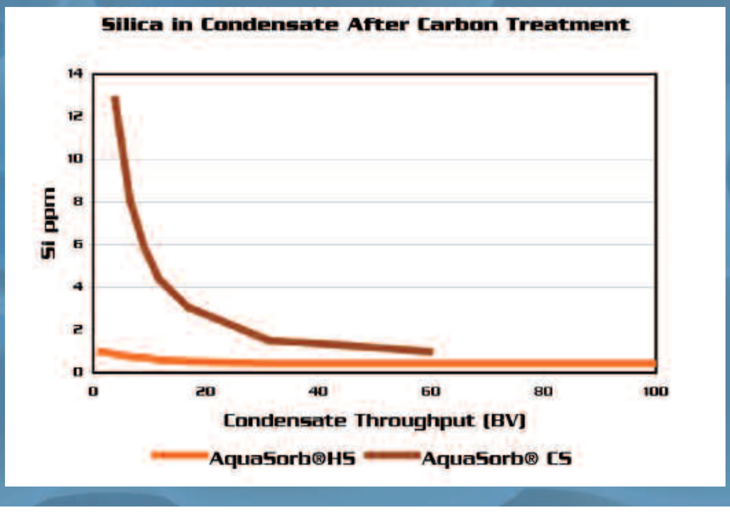


Figure 2: Silica in Condensate After Carbon Treatment



As described previously, should hydrocarbon loads exceed 5mg/L, the process stream should be pre-filtered to prevent premature fouling of the carbon adsorbent by liquid oil droplets. This filtration should use anthracite or similar carbonaceous media as the recommended pre-filter media. It is important to note that sand should not be used as a filtration media as it will increase the silica content of the condensate (see Figure 1).

When recycled condensates are to be used as boiler feed water for medium or high pressure boilers, a down stream ion exchange unit must be installed in order to prevent trace quantities of minerals leached from the activated carbon effecting the efficiency of boilers and turbines. It is the responsibility of the plant operator to ensure that the amount of silica leaching from the activated carbon is within the required limits prior to commencing start-up of the boiler/turbine system.

Typically activated carbon contains silica in its ash and this must be washed out during the start-up procedure, in order to avoid silica leach that is detrimental to high-pressure boilers and power generating turbine systems. Deposition of silica in boiler tubes creates similar heat exchanger problems to coking from oil in condensate.

Deposition of silica on turbine blades in power generation equipment is much more problematic as it can result in unbalancing the high-speed rotation of the turbine and can induce catastrophic axle failure.

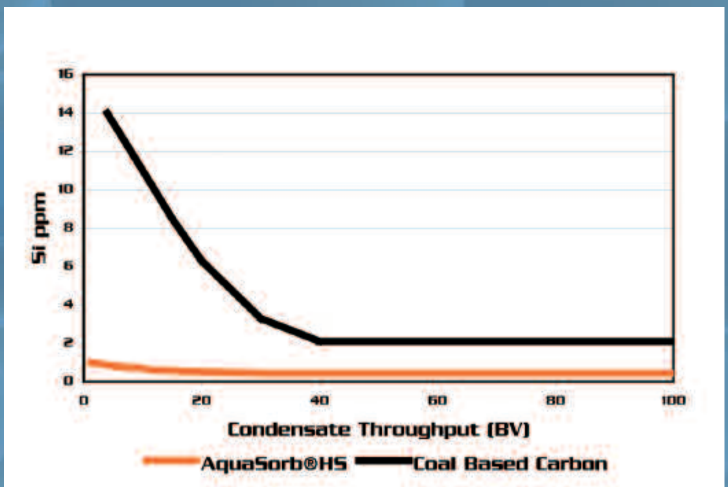
AquaSorb HS is specially acid washed to remove soluble silica ash and is characterized by very low silica release into condensate (see Figure 1) after initial back washing and is the Jacobi Carbons grade recommended for condensate de-oiling systems.

Active Carbons for the Removal of Hydrocarbons from Condensate. AquaSorb HS. AquaSorb HS is an acid washed high purity high activity granular activated carbon manufactured by steam activation

Table 1: Comparison of AquaSorb HS and pelletised coal carbon

Property		AquaSorb HS	0.8 mm Coal Pellet	Acid Washed 0.8mm Coal Pellet
Bulk Density	kgm^3	510	410	410
Ash	wt%	0.5	8	3
Iodine No.	mgg^{-1}	1050	1050	1050
Surface Area	m^2g^1	1100	850	900
Hardness	%	99	94	92
Moisture	wt%	2	2	2

Figure 3: Silica in Condensate After Carbon Treatment



from carefully selected coconut shell charcoal. This grade is particularly suited for ultra-pure water treatment systems requiring low conductivity and exceptionally high purity. This material is also specifically recommended for the removal of heavy hydrocarbons from condensates.

The acid washing process removes soluble silica (SiO_2) from the matrix of the activated carbon to prevent leaching into the condensate.

When used for the removal of hydrocarbons from condensate, AquaSorb HS is characterized by a large adsorptive capacity for oil (approximately 30 weight percent), and levels of silica release into condensate that are much lower than that typical for standard coconut carbons.

Table 1. above, allows a comparison of the physical properties of AquaSorb HS with typical coal based pelletised carbons at 0.8 mm diameter (both standard and acid washed grades) based on commercially available data.

AquaSorb HS offers distinct advantages over such coal based pellets by being denser, harder and lower in ash.

As AquaSorb HS possesses a 20 percent greater density than coal, based pelletised products an adsorber loaded with AquaSorb HS will exhibit a greater hydrocarbon capacity overall as it contains 20 percent more carbon. The high hardness of the AquaSorb HS results significantly less attrition of the carbon in the adsorber and lower release of fine carbon particles into the condensate during adsorber operation. However, most importantly in respect of condensate treatment applications, the higher purity of the AquaSorb HS (less than 25 percent of the ash content of the acid washed coal pellet) means that the product offers much less silica leach into condensate significantly reducing back wash requirements and reducing the risk of potential boiler or turbine problems. Coal based carbons produce significantly greater silica leach than coconut based carbon products as their ash composition contains a large alumino-silicate content and even after acid washing this can only be reduced to approximately 3 percent residual ash (see Figure 3 on page 17).

Plant operational experience has confirmed that AquaSorb HS requires significantly less backwashing than the acid washed coal based pellet products to achieve required silica release levels.

AquaSorb HS required 100 bed volumes of backwashing to achieve SiO_2 of less than 0.1 mg/L at 80° C whereas an acid washed 0.8 mm coal based product required approximately 1,000 bed volumes. **WQP**

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