Norit Activated Carbon
leading in purification

TECHNICAL BULLETIN

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Hydrogen Sulfide Removal from Air Using Activated Carbon

Introduction

Nuisance odors are those malodors, which the public find offensive and are emitted from many industrial processes. Facilities that have potential odor removal needs include: wastewater treatment plants (WWTP), pumping/lift stations, landfill sites, composting facilities, waste disposal sites, waste transfer stations, restaurants, dairy processing, food processors, breweries, slaughter houses, chicken & pig farms, foundries, pulp & paper manufacturers, ethanol plants, automobile manufacturers, and most industrial effluent treatment plants. Odors emitted from these facilities can range from simple malodours to very complex mixtures of gases. In processes where biological activity is present, hydrogen sulfide (H_2S), organic sulfur species, ammonia (NH_3), and various mercaptans are the species that cause the majority of the odor. The removal of H_2S generally results in a large decrease in the malodor level.

Activated Carbon

There are 3 basic types of activated carbon: Catalytic Impregnated (Regenerable), Impregnated carbons and Non-impregnated (virgin). Each has benefits and drawbacks for odor control treatment. One of the most crucial properties of the carbon is the H_2S loading capacity by the ASTM D-6646 test method. The test determines the H_2S loading capacity measured in grams of H_2S removed per cubic centimeter of activated carbon (g/cm^3). A detailed description is given below for each type of carbon:

- **Catalytic Impregnated Activated Carbons**
  Catalytic activated carbons are manufactured in specially controlled environments, which include treatment with urea or some other chemical containing nitrogen. The urea or other chemical reacts with the surface sites on the activated carbon particles and adds nitrogen functionality. Catalytic carbons are said to be water regenerable. In practical use, few locations water regenerate catalytic activated carbon due to the large volume of water required and the acidic stream that is produced. The few locations that do water regenerate achieve 2 - 3 loading cycles of diminishing runtime. Catalytic activated carbons have specified H_2S loading capacities around 0.09 g/cm^3.

- **Impregnated Activated Carbons**
  Impregnated carbons are those to which a solid or liquid chemical has been mixed with the carbon substrate before, during or after activation. The main chemicals used as impregnates include magnesium oxide (MgO), sodium bicarbonate ($NaHCO_3$), sodium carbonate (Na_2CO_3), sodium hydroxide (NaOH), potassium hydroxide (KOH), potassium iodide (KI), and potassium permanganate ($KMnO_4$). Mixtures of these chemicals are sometimes used. A typical H_2S loading capacity for caustic impregnated carbons is 0.14 g/cm^3. Strong base impregnated carbons are considered regenerable by re-application of the strong base. This is a dangerous practice and can cause the carbon to be classified as Hazardous including the treatment area. Norit strongly recommends this treatment not be performed due to the risks involved.

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- **Non-Impregnated Activated Carbons**
  The non-impregnated activated carbons used for H_2S removal vary widely in loading capacity. NORIT® VAPURE 410, NORIT® VAPURE 612, and NORIT® VAPURE 460 are non-impregnated activated carbons in this category. These products have H_2S loading capacities around 0.02 g/cm^3. They typically have higher VOC loadings than impregnated carbons.

  DARCO® H_2S is a revolutionary non-impregnated activated carbon with a H_2S loading capacity of 0.2 g/cm^3 repeatedly confirmed by three independent laboratories. DARCO H_2S costs about the same as other non-impregnated activated carbons used for H_2S removal and has 4 - 10 times the loading capacity. Spent carbon disposal issues are also reduced with DARCO H_2S (see page 3, Spent Carbon Disposal).

Equipment

The corrosive nature of H_2S requires appropriate materials of construction for the treatment equipment. Fiber reinforced plastic (FRP) vessels, ducts and blowers are typically recommended. Norit Americas Inc. can assist in the design of the odor control system and supply nearly all types of systems including FRP.

Bed Design

- Empty Bed Contact Time (EBCT) of 3 - 6 seconds or more
- Linear Velocity of 10 - 60 ft/min (5 - 30 cm/s)
- Minimum Bed Depth ~2 ft
- Oxygen is required for effective performance (more than 4 times the H_2S concentration on a molar basis is normally sufficient).
- Moisture is required to achieve high loading on DARCO H_2S. A minimum relative humidity of 30% (preferably higher) is recommended.

Bed Fires

Strong base impregnated carbons have historically been associated with increased risk of bed fires. Bed heat up is initiated by the hygroscopic nature of the base impregnate and the chemisorption of water and oxygen on the carbon substrate. When starting up an odor control system using activated carbon, it is best to start the system immediately after the installation of the carbon and leave it running. Starting and stopping the flow of air increases the risk of bed fires. An activated carbon bed should be put into service immediately to prevent the heat generated from chemisorption, during the installation of the carbon, from increasing the bed temperature. Starting airflow through a hot carbon bed may cause any hot spots to start smoldering and in some cases flame. A similar phenomenon is observed by blowing on red-hot charcoal briquettes.

Particle Size and Pressure Drop

Particle size has an impact on pressure drop for an odor control system. Gas phase activated carbons range from 4X8 mesh granular particles to 3 and 4 mm extruded pellets. DARCO H_2S, being a 4x8 mesh GAC, tends to have a slightly higher pressure drop than 4 mm extruded pellet activated carbon (See Figure 1). In most cases, higher-pressure drop can be eliminated by using larger diameter contactors with more shallow beds and still maintain the minimum ~2 ft bed depth. The carbon volume and contact time remain the same.

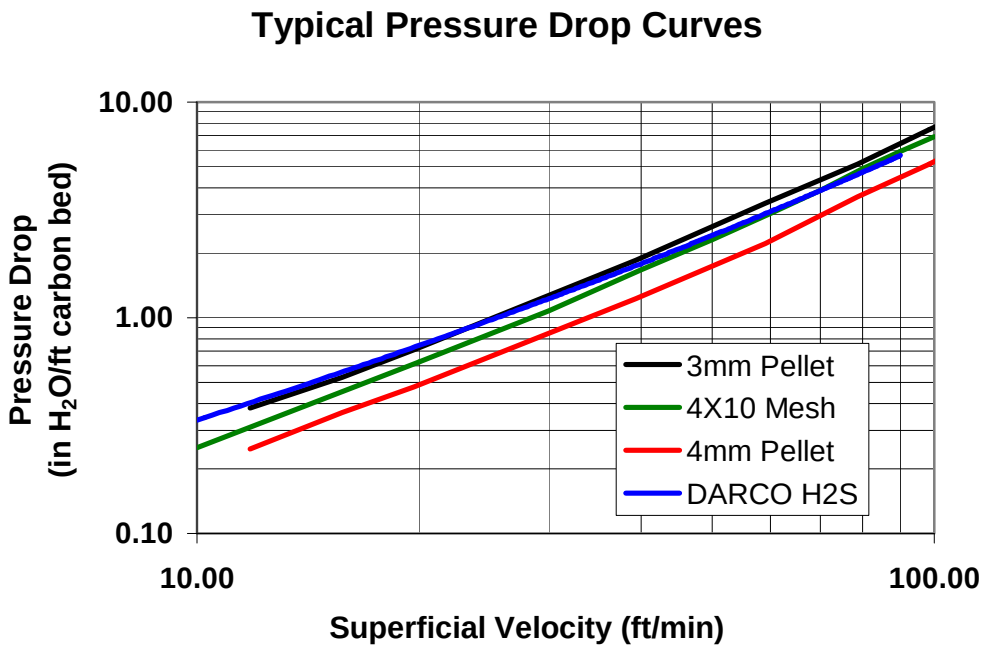

Figure 1. Typical pressure drop curves for gas phase carbons.

Spent Carbon Disposal

Some activated carbons loaded with H_2S are considered hazardous due to pH less than 2. Spent catalytic impregnated carbons may be hazardous due to the low pH of their water extract. The byproduct of the adsorption of H_2S is elemental sulfur with a pH of 4. Therefore, spent DARCO H_2S is considered suitable for landfill. Careful review of all local, state, and federal regulations should be made before disposing of any spent material.

H_2S Loading Capacity Survey Using ASTM D-6646

Samples of several types of activated carbons were tested by multiple independent laboratories for H_2S loading capacity using ASTM D-6646. ASTM D-6646 reports mass H_2S loading per unit volume. Vibrating feed apparent densities (VFAD) were measured according to ASTM D-2854 by Norit Americas, Inc. and used to calculate the mass H_2S loading by unit weight. DARCO H_2S, Midas[3], and HSV[5] were pre-humidified per ASTM D-6646 before testing.

Test results are shown in Figure 2 on the next page.

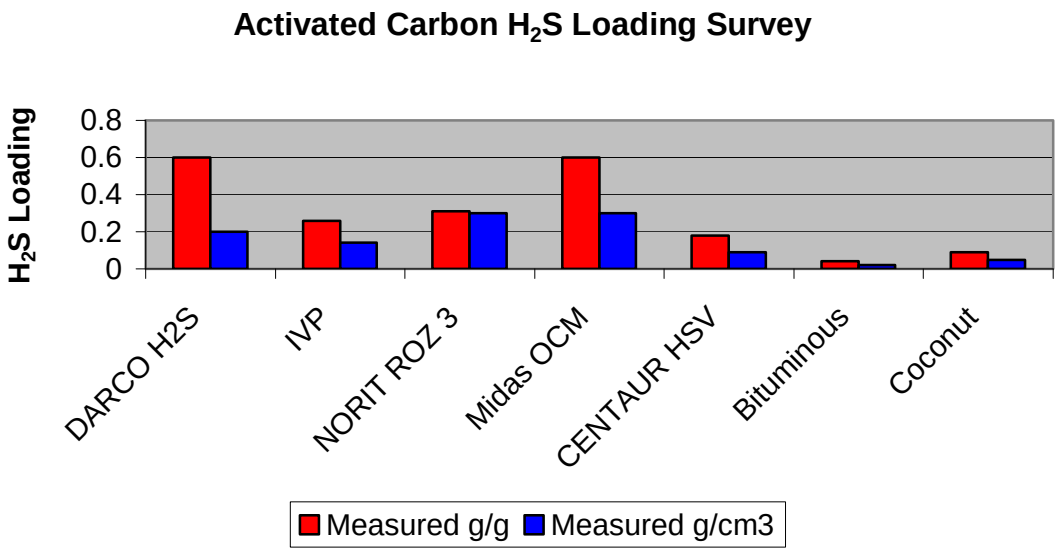

Figure 2. H_2S Loading Capacity Survey using ASTM D-6646

Economic Considerations

Activated carbon used to remove H_2S varies a great deal in price as shown below in Table 1.

Activated Carbon Pricing ($/lb)		
Activated Carbon Name	**Type**	**Estimated $/lb**
DARCO H_2S	Non-Impregnated	1.20
IVP[2]	Impregnated	1.15
NORIT ROZ 3	Impregnated	3.50
Midas OCM[3]	Impregnated	4.00 - 5.75
MINOTAUR OC[4]	Impregnated	4.00 - 5.75
CENTAUR HSV[5]	Catalytic Impregnated	2.25 - 3.75

Table 1. Estimated Activated 2008 carbon pricing in $/lb.

Please contact manufacturer or distributor for accurate pricing.

Conclusions

The combination of high H_2S loading and economical price for a non-impregnated product make DARCO H_2S THE BEST activated carbon for removing H_2S from air.

Notes

[1]Phone Call with Black and Veatch LLP. May 2005.
[2]Calgon Carbon IVP
[3]USFilter Westates Midas® OCM
[4]Calgon Carbon MINOTAUR™ OC
[5]Calgon Carbon CENTAUR® HSV

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