

GAC Water Treatment: Capital Equipment

Model 6, Model 8, Model 10, Model 12

Description

Calgon Carbon Corporation offers a complete line of carbon adsorption systems designed for efficient and cost effective organic contaminant removal from water, wastewater, and process liquids. System sizing accommodates a wide range of flow rates and granular activated carbon quantities, allowing the system to be optimized for capital and operational costs.

Calgon Carbon adsorption systems represent 30 years of experience in system design and operation, and include all of the components necessary for a complete operating system. Adsorber vessels are steel pressure vessels constructed to and stamped in accordance with ASME Code. Standard internal linings are thick film vinyl ester linings to assure satisfactory equipment life and minimize maintenance. The underdrains have been designed to create even flow through the adsorber, providing higher contaminant loading and system efficiency through effective use of the carbon. The underdrain also provides low pressure drop across the adsorber, efficient collection of treated water, and effective distribution of backwash water. The pre-engineered designs are flexible, allowing changes in materials of construction, vessel linings, manway sizes, underdrain designs, process pipe sizes, valves, and instrumentation to fit specific requirements.

Adsorption System Designs

Calgon Carbon Corporation uses three basic designs for adsorption system selection.

1. Model 6 - two 6' diameter adsorbers each containing typically 6,000 pounds of GAC
2. Model 8 - two 8' diameter adsorbers each containing typically 10,000 pounds of GAC
3. Model 10 - two 10' diameter adsorbers each containing typically 20,000 pounds of GAC
4. Model 12 - two 12' diameter adsorbers each containing typically 20,000 pounds of GAC

These basic systems, with added flexibility in material selection and detail design allow Calgon Carbon to accommodate most water treatment or liquid applications. Systems may be provided as single adsorbers, or in multiple systems to accommodate larger flows or special situations. The primary difference between these designs involves the vessel diameter and pipe size. Changing the vessel diameter changes not only the carbon volume, but the surface area that will determine pressure drop and backwash characteristics. The critical aspects of adsorber design are:

- Contact time (empty bed basis) - relationship between amount of carbon and flow rate that establishes that adequate carbon is on-line to contain the adsorption process.
- Pressure drop - based on pipe size, underdrain design, surface loading rate, and carbon granule size distribution.
- Carbon type and quantity - determines capacity for the contaminants (exchange frequency) and cost of initial fill or carbon exchange.

The maximum quantity of GAC in an adsorber vessel is set at 20,000 pound due to the transport weight constraints of the trailer removing the spent carbon from the site. When drained, one pound of dry carbon contains approximately one pound of water plus the adsorbed contaminants. Thus any vessel containing more than 20,000 pounds would likely require more than one truck to contain the contents from an adsorber. If a larger amount of carbon is called for, multiple units may be used in series or parallel. Adsorbers can be designed with greater than 20,000 lbs GAC, however the spent carbon removal will require special procedures and handling, or other transportation considerations.

The Calgon Carbon systems reviewed here have the capability for backwash and may be operated in series or as parallel units. Each adsorber of the pair may be isolated for backwash or carbon exchange, with the other adsorber remaining on-line if necessary. System specifications include:

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Table 2

The budgetary equipment prices in Table 2 take into account variables including: pipe size, carbon amount and type (virgin/react), and equipment freight. To determine the total capital cost for a project include the equipment cost (Table 2), the installation cost (Table 2), field supervision, foundations (site specific costs), winterization (site specific costs), and carbon freight. The cost of carbon freight can range from no additional cost, when carbon is shipped in the vessel (for Model 6 or 8 only), up to \$5,000.

Additional Site Requirements

The installation of a GAC adsorber requires a flat foundation for either modular or skid mounted systems. The standard design of this equipment is modular consisting of two (2) vessels set directly on a foundation with a central self supported valve rack. This set-up is intended for installation on a concrete foundation. The units are shipped as separate pieces and set by field personnel. A steel skid can be provided as an option to provide a framework on which to set the two vessels and valve pipe rack. Foundations should have a slight slope to allow drainage, curbing is optional. A clean water source should also be available to allow for slurry transfer of fresh carbon, initial wetting, deaeration, and backwashing. A compressed air source (temporary or permanent) is used to transfer the carbon slurry from the vessel into a receiving trailer; or for the transfer of carbon from the trailer to the adsorber (100 cfm @ 15 psig). The site should have provisions to handle the volume of backwash water. As a guideline, design the holding tank or facilities to contain 15 gpm/ft² for 20 minutes.

Truck access is required for carbon fill or exchange. Trailers are typically 41' long (with tractor 55') by 8' wide by 13' tall. The maximum truck weight is 120,000 pounds during change-out (when full of water). The truck needs to be able to be located within 20' of the carbon fill line on both adsorbers. The site may require an apron and drain water connection to allow the truck to drain any water from the spent carbon transfer.

Operations and Operational Costs

The operation requirements for Calgon Carbon permanent adsorption systems varies based on the water being treated, the complexity of the treatment system, and the operating practices of the site. In general, only periodic monitoring is required. Carbon removal and replacement for these large units is usually not frequent (again depending on the carbon usage rate). Any estimate must therefore be done on a site-by-site basis. There are, however, some similarities of operation that can be discussed.

Carbon Acceptance Testing - This is a one time test, performed by our laboratory staff, that ensures the spent carbon can be safely managed and effectively reactivated. A test canister is provided to be put in line with the unit, exposed to the influent water, and then returned to Calgon Carbon. The fee for this testing is either \$400 for non-RCRA or \$1,000 if the spent carbon return is to be RCRA manifested.

Testing required for the determination of RCRA status is a separate set of tests done by the customer's responsible environmental personnel.

Activated Carbon Removal and Replacement - Carbon exchange plays a significant role in the cost of operating a carbon adsorption system. The spent carbon must be removed from the adsorber vessel and safely handled. Three treatment options exist for spent carbon: disposal, destruction, and reactivation. The decision as to which method of handling spent carbon should be used depends on the contaminants, operations, economics, and customer preferences. Reactivation is generally favored and will facilitate the destruction of organic contaminants on the carbon while allowing the carbon to be reused. The replacement

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carbon should be of the same quality as the initial fill whether it is virgin or reactivated grade carbon. This will provide the same contaminant removal, consistent bed life characteristics, and stable system operations.

Calgon Carbon provides carbon exchange services, including removal of the spent carbon for reactivation, at an estimated cost of \$0.55-\$1.10/pound for virgin grade carbon and \$0.50-\$0.70/pound for reactivated carbon. Freight to the site and return freight to the react facility must also be added to these cost estimate values. In order to minimize freight costs, many transfers may be accommodated with multiple compartment trailers, which manage the exchange with a single trailer. In addition, Calgon Carbon maintains three reactivation centers, strategically located, to further optimize costs and response. Reactivated grade carbon is pooled from the reactivation process and quality controlled to provide consistent quality and adsorptive characteristics.

Maintenance - The cost of maintaining a well-designed adsorption system is low. The systems have been designed to run with only periodic inspection (generally at carbon exchange). Maintenance costs will vary with system complexity, the corrosiveness of the water being treated, the frequency of carbon exchange, and suspended solids in the water entering the vessels. Frequent carbon exchange or backwash operations may affect lining wear and increase maintenance costs. Annual maintenance costs may be expected to fall in a range of 5% to 10% of the installed capital costs. Calgon Carbon's experience in maintaining adsorption systems for customers over the past twenty five years indicates that costs average 5% of the capital cost for a system that changes carbon every two months or less, treats neutral water, and has no automation. The internal adsorber linings should be inspected at carbon exchange or at scheduled intervals based upon the corrosiveness of the water and the frequency of carbon exchange. Calgon Carbon can offer major maintenance service packages to manage inspection and preventative maintenance programs to optimize on-line system life.

Operation - An operator is not required on a continuous basis, as usually backwashing and carbon exchange are the only two operations for which operator attention is required. Calgon Carbon's exchange service requires between two and four hours of operator service, and the driver/technician will operate the truck and all trailer functions. If a service other than Calgon Carbon is used, costs will include spent carbon discharge, dewatering, packaging transport off-site, and the fresh carbon fill. Backwashing requires on the average thirty minutes of operator time to isolate the vessel, backwash the bed, and return the adsorber to service.

Monitoring - Monitoring a modular adsorption system is divided into two areas; hydraulic and analytical. Hydraulic monitoring requires an operator to note the physical operation of the system, including pressure drops, flows, and a check for leaks. The frequency of this type of examination depends on the characteristics of the water being treated (suspended solids, corrosiveness, and flow rate).

Analytical monitoring consists of taking and analyzing water samples, the frequency of which depends upon the requirements for the site. Other factors, which influence monitoring frequency, are critical effluent quality (discharging directly off-site under permit or into potable water systems) or expected carbon exchange frequency. Adsorption systems are normally monitored for influent quality, effluent quality, and inter-stage quality (two stage systems). For single stage and parallel systems, in bed sampling may be used to more accurately predict breakthrough time and carbon exchange frequency.

There may be other factors involved in the cost of operating an adsorption system, including any pretreatment or material management costs. Pretreatment to improve the operation of the adsorbers will depend on the quality of the influent stream and may include filtration to more effectively reduce suspended

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solids, equalization to lower design flow and optimize system capital costs, or other organic removal processes such as oxidation to optimize overall treatment costs. Material management for spent carbon and arrangements for a fresh carbon supply will affect the cost of operating. Some of the operating costs described may be eliminated or optimized by entering into a service agreement that can cover either carbon exchange or complete system management.

Complete Service Option

In addition to adsorption system sales, Calgon Carbon offers a complete service approach, where Calgon Carbon maintains ownership of the system and provides maintenance and carbon exchange services for ongoing monthly and/or specific fees.

Summary

Calgon Carbon has extensive experience in the design, installation, operation, and maintenance of permanent liquid phase carbon adsorbers. This experience along with the use of pre-engineered systems allows a quick customer response time that can provide from firm economics to detailed engineering for the system design. High quality design and construction, including ASME code vessels, proven underdrain design and protective vessel linings, provide improvements to both efficiency and system lifetime. Accurate cost estimates may be provided for both start-up and operational costs from Calgon Carbon's extensive experience. This makes liquid phase carbon adsorption a versatile and cost effective method of treating many contaminated water streams.

Advantages of Pre-engineered Adsorption Systems

The use of pre-engineered systems has many advantages for the user:

- Low Capital Costs; Basic engineering package complete and use of Calgon Carbon standard inventory
- Low Operating Costs; Design optimizes carbon usage and maintenance
- Expedited Delivery; Systems may be in inventory or fabricated from stocked material
- Proven Results; System designs are based on 30 years of designing and operating carbon adsorption systems

Checklist for adsorption system design

- Carbon Usage Rate
- Carbon Adsorption System Selection (flow rate, carbon exchange frequency)
- Capital and Operating Cost Estimates
- Carbon Adsorption System Design (specification and design cut sheets available)
- Carbon Adsorption System Proposal