

Equipment Solutions For Storing And Feeding A Hard-To-Handle Material Such As Activated Carbon

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Do you handle a fine, lightweight material that's dusty, hard to feed, and floods or compacts easily? Is your material abrasive and hard on pneumatic conveying elbows? Or have you found that the material doesn't readily form a dust cake on your dust collector media, preventing efficient filtering? Read this article for information on how one hard-to-handle material, powder activated carbon, can be stored and fed in both dry and slurry forms with the right equipment. You can apply many of the principles to your own hard-to-handle material.

Some challenging storage and feeding problems face those of us handling fine, lightweight powders. One such material is Powder Activated Carbon (PAC). Each PAC particle has an extremely large surface area with micro pores, which helps it easily absorb gasses and heavy metals.

Power plants that burn coal and cogeneration plants that burn refuse use PAC in dry or slurry form for reducing mercury emissions, which helps the companies meet federal and state clean air requirements. Other PAC users include municipal water treatment plants, which use the PAC in slurry form to remove taste and odor from drinking water.

But despite PAC's usefulness in cleaning up our environment, the powder is hard to handle. PAC's very fine size distribution - 100 percent minus 400 mesh with as much as 10 percent less than 5 microns - makes the powder dusty and likely to flood or compact. The powder is also abrasive, doesn't readily form a dust cake during filtering, and is insoluble in water, which means it can settle out in a pipeline.

The following information, which can be applied to hard-to-handle materials other than PAC, analyzes each of these handling problems and presents equipment solutions. Specific areas discussed are storage, dry feeding, and slurry forming.

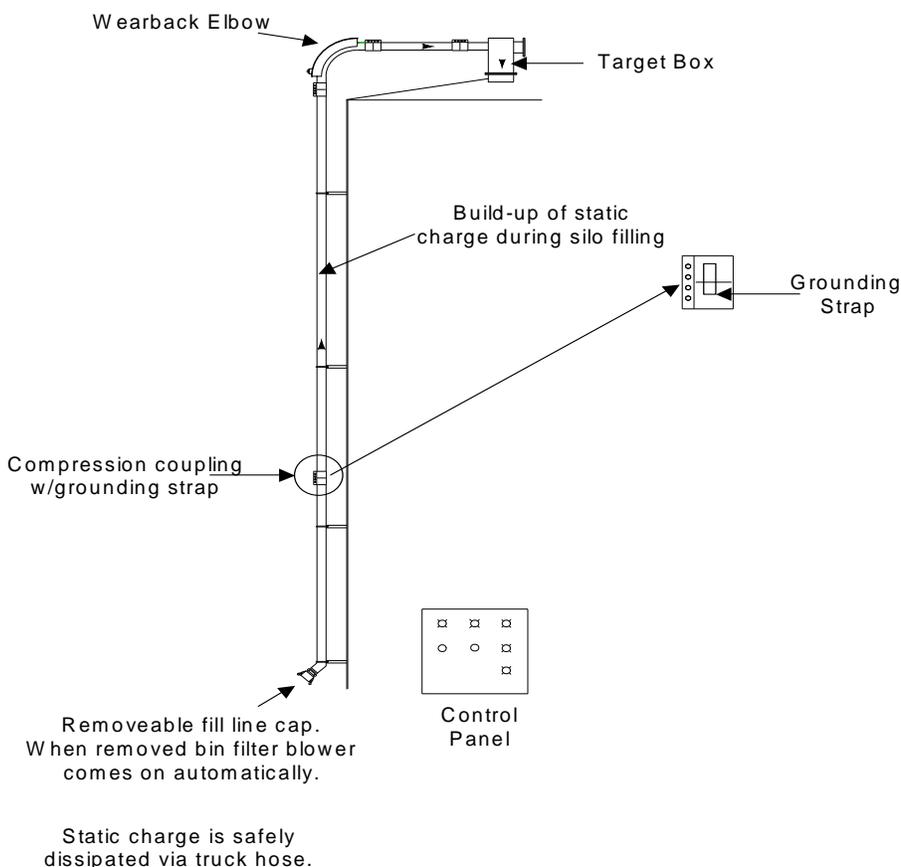
1. STORAGE

Problems in storing PAC center on how the powder is pneumatically loaded into the silo, how dust is collected during loading, and how stored PAC is prevented from leaking.

Pneumatic loading. Storing a large amount of PAC locally requires regularly loading it into a silo (or other large storage vessel). Typically, the powder is pneumatically transported from a truck unloader that can hold from 1,000 to 1,200 cubic feet of powder, which is up to about 24,000 pounds of PAC. The

PAC is conveyed through the truck hose, which is typically flexible, into the silo's fill line, which is typically a rigid steel pipe, and into the silo. The unloader's hose has an inlet pressure of 6 to 8 psig, so loading a truckload of PAC into the silo can take from two to three hours. The unloading time can be reduced by increasing the transfer pressure to 10-12 PSI, but this change will increase wear on the silo fill line and long radius elbow.

Silo Fill Line



While you may be tempted to increase the line pressure to speed loading, don't use a pressure higher than 12 psig. A higher pressure will create a high

conveying velocity that can accelerate wear in the silo's fill line. To compensate for this wear:

- Use schedule 80 or thicker pipe for the fill line.
- Use wear-resistant ceramic or wear-back elbows with a radius of no less than 4 feet.

Using a line pressure higher than 12 psig can also pressurize the silo, causing dust to escape into the environment. Make sure any line pressure increase doesn't raise the silo pressure above its design pressure (about 0.25 psig). [Authors' note: The conveying line pressure decreases from 12 psig to <0.25 psig due to expansion in the silo.] A line pressure increase above the design pressure will open the silo's pressure-relief valve and send a plume of dust into the air.

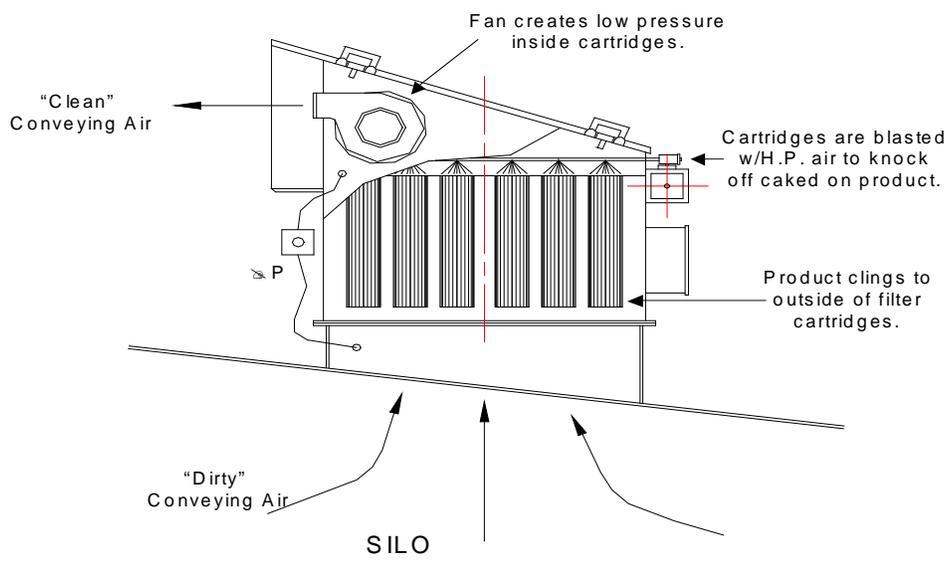
Pneumatically loading PAC can also create a static electricity problem. If you don't properly ground the silo's fill line, the PAC rubbing inside the line will cause friction that builds up a static discharge. A sudden static discharge can cause a spark and, if the spark temperature exceeds the PAC dust ignition temperature of 800°C, can trigger a slow burn. To eliminate static charge build-up and prevent the potential for a fire, use only conductive pipe joints on the fill line and properly ground the entire silo system.

Collecting dust during loading. A bin vent releases the air introduced into the silo during pneumatic loading. The bin vent is typically equipped with a dust collector that uses bag or cartridge filters of tightly woven media, such as polyester, to capture the dust particles. The dust collector has either a shaker for filter bags or pulse-jet mechanism for filter bags or filter cartridges to dislodge the collected dust from the filters so it drops into the silo. During initial PAC loading, the filters quickly trap a large percentage of the dust, forming a dust cake on the filters. However, for just a few minutes during this stage of dust build-up, it's common to see dust exiting the bin vent exhaust.

As the dust cake thickens, it performs the remaining filtering at increasing level of efficiency. Use a pressure differential gauge that measures the pressure drop across the filter media to check that the pressure drop doesn't exceed 10 inches of water column. Because PAC doesn't cake as easily as other powdered chemicals, it can take longer for the dust cake to form and reach the desired filtering efficiency. You can improve filtration by using surface-filtration media, such as Gore-Tex, which has smaller holes to speed dust cake formation.



Pulse-jet Type Dust Collector



Of the two dust collectors, the pulse-jet type is better for removing PAC. The shaker unit cleans the filters only after pneumatic loading is complete. The pulse-jet unit provides better filtration because it continuously repeats the cleaning cycle through all the filters during pneumatic loading until all filters are clean. The pulse-jet dust collector can clean the filters based on a timer's preset cycle or in response to sensing a high pressure drop across the filter media. In the latter case, for instance, the cleaning cycle can start when the pressure drop exceeds 6 inches water column and stop when it falls below 4 inches water column.

You can also increase the allowable dust collector's pressure drop and improve the bin vent's filtering job by using an exhaust blower on the dust collector.

Preventing silo leaks. The fine PAC particles can stream from minute weld pores (called pinholes) and unsealed flanges in the silo. During pneumatic loading, a barely visible pinhole in a weld can release a significant stream of PAC. Such a pinhole is extremely hard to plug with an epoxy, and spot welding the pinhole after the silo is filled with PAC can create a fire hazard. To ensure your welds have minimal porosity, run dye-penetrant tests on them during silo fabrication.

To seal the silo flanges, use a flowable sealant such as silicone caulk. Carefully apply a double bead of caulk (one bead inside the flange periphery and one outside), allow the caulk to partially harden, then join the flange faces.

2. DRY FEEDING

The next step in handling PAC is withdrawing it from the silo and feeding it into the flue gas. Feeding PAC requires special care to avoid flooding or compaction. This section discusses how you can use a live bottom in the silo's discharge cone and a volumetric feeder below the live bottom outlet to overcome PAC's tendency to flood or compact.

Using a live bottom. PAC's fine particle size and easy flowability can cause it to either flood through or compact in the silo. Flooding occurs when powder flows uncontrollably through the volumetric screw or belt feeder or when, after the powder has bridged in the silo, the bridge suddenly collapses and releases a surge that overwhelms the feeder. Compaction can occur when the live bottom's discharge rate and feeder's feedrate don't match. For instance, if the live bottom discharges faster than the feeder below it, the PAC backs up in the silo's cone and compacts. Compaction can also occur when the live bottom runs too frequently or too long.

By installing and properly operating a live bottom in your silo's discharge cone to condition the PAC, you can help to overcome both problems. The live bottom can be either a bin activator, which applies intermittent mechanical gyrations to the powder, or an air fluidizer, which applies intermittent high-pressure air pulses or continuous low-pressure air to fluidize the powder. When a powder is fluidized it flows similar to a liquid. When the fluidization method is used, the PAC feeder must be a rotary positive-displacement volumetric feeder.

To prevent both flooding and compaction, adjust the live bottom's intermittent on-off cycle to match the feeder's feedrate. The higher the feedrate, the longer and more frequently you'll run the live bottom. You can determine the best on-off cycle by carefully experimenting with various cycle times and observing the results. To prevent problems when using a fluidizer make sure the fluidizing air is dry and the air pressure is under 10 psi in the case of low-pressure fluidization.

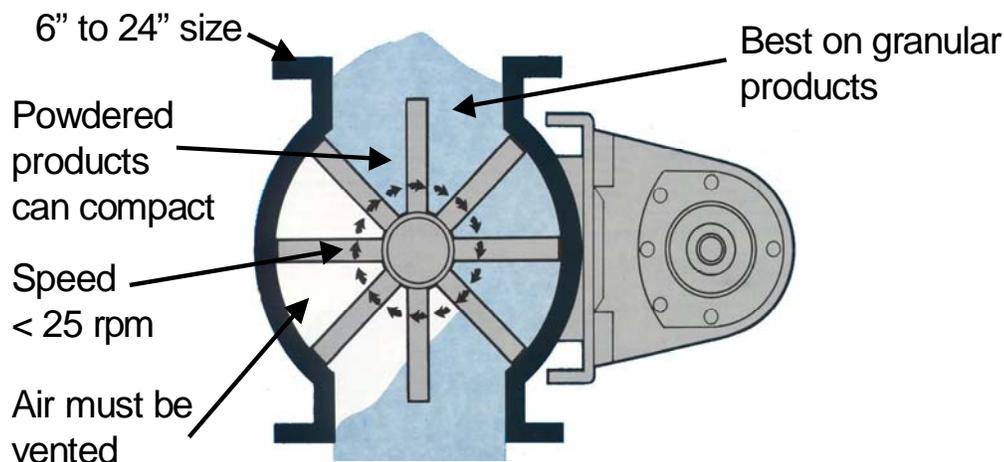
Using a volumetric feeder. Two types of volumetric feeders- the rotary airlock and screw feeder- are commonly used for feeding PAC. The rotary airlock consists of several vanes mounted on a rotor inside a cylindrical housing; the housing is mounted below a transition section under the silo discharge cone. As the rotor rotates, the vanes spin and PAC falls from the silo, through the transition section into the housing, and fills the pocket or space between the two upward-facing vanes. The vanes advance to seal the pocket so it's airtight. As the pocket rotates to its lowest point, the pocket opens and discharges the PAC by gravity.

The rotary airlock can be used as a high-volume feeder or as a prefeeder ahead of a screw feeder to prevent flooding through the screw feeder. For

high-volume feeding ($100\text{ft}^3/\text{hr}$ or more), install the rotary airlock below the live bottom and directly above the subsequent flue gas or wastewater treatment process. For use as a prefeeder before the screw feeder (at a feedrate less than $100\text{ft}^3/\text{hr}$), install the rotary airlock below the live bottom with a small interim hopper that is mounted between the airlock discharge and the screw feeder inlet. This permits the screw feeder to feed continuously

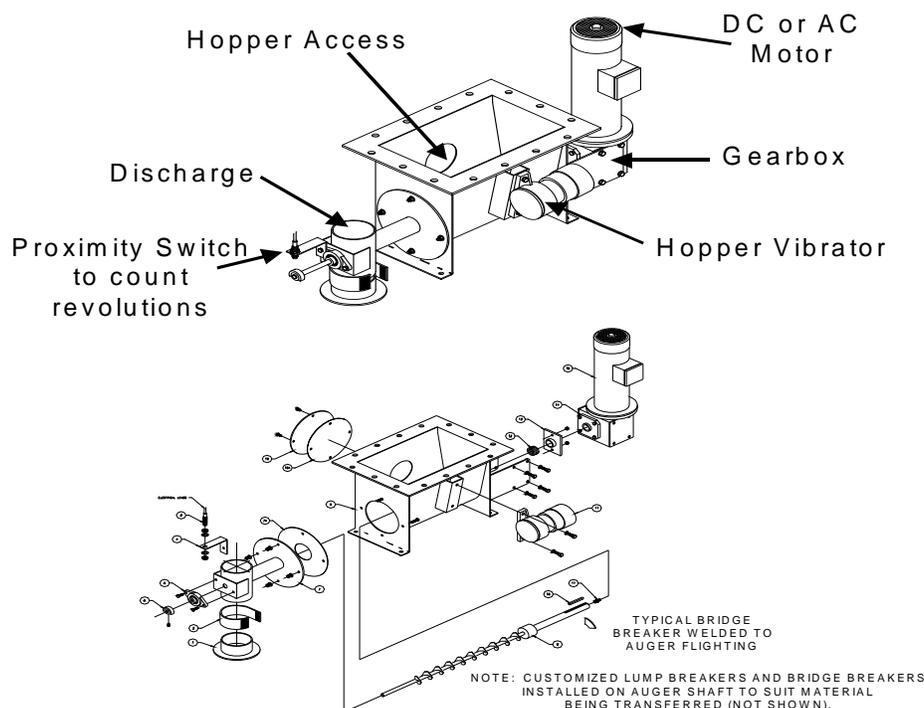
while the rotary airlock runs intermittently, based on the PAC level in the interim hopper. Make sure the live bottom is cycled on and off so the PAC is flowing whenever the prefeeder is turned on.

Rotary Feeders (Valves)



The screw feeder consists of a screw with closed flights (called a solid-shaft screw) or with open flights (called a helix) encased in a discharge tube. As material enters the tube, the advancing screw flights capture material and push it along the tube toward the discharge. The screw feeder is used for PAC feedrates less than $100\text{ft}^3/\text{hr}$.

To prevent flooding, select a screw length inside the feed tube of at least six times the length of the screw pitch. It's also typically better to use a solid-shaft screw than a helix. The light, fluffy PAC tends to flow through the helix's open area even when the feeder is turned off. But you can use a helix if you install a rotary airlock prefeeder that controls the PAC flow to the screw feeder. To prevent PAC from leaking from the screw feeder hopper, also use a shaft seal arrangement that includes rotating and stationary seal faces rather than just a couple of packing rings along the shaft. Otherwise, the small PAC particles can squeeze through tiny imperfections in the shaft surfaces.



Chemco Screw Feeder

Besides matching the live bottom's discharge rate to the feeder's feedrate, you can prevent compaction by avoiding the use of a hopper vibrator with the screw feeder. The vibrator not only can cause compaction but can potentially damage the screw feeder. You can safeguard the screw feeder from compaction damage by carefully selecting screw feeder options. For instance, if the PAC is severely compacted, the screw flights can become deformed or the screw shaft can shear. You can prevent resulting damage to the feeder's gearbox and motor by equipping the feeder with a mechanical clutch. You can also use a shaft zero-speed switch, which detects the non-rotating shaft and sounds an alarm before the shaft can be damaged.

With either a rotary airlock or screw feeder, you can prevent flooding by using an air-or motor-actuated valve between the live bottom outlet and the feeder inlet. The valve automatically closes for the first few seconds of the live bottom's on cycle, then opens and allows the PAC to flow into the feeder inlet.

To reduce abrasive wear, select an airlock or screw feeder made of an abrasion-resistant material. Common examples are high-chrome and Ni-hard steel. Such materials cost more, and are more costly to machine, than standard construction materials. While this increases the equipment's capital

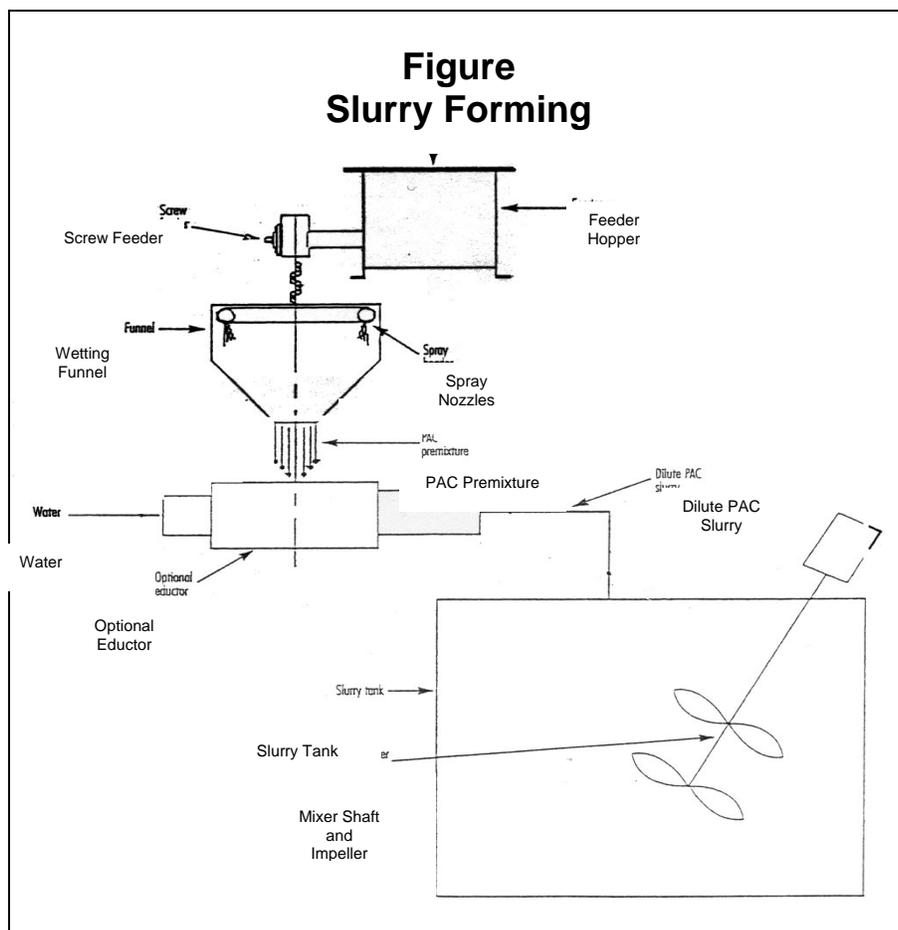
cost, the wear-resistant material can improve the equipment service life and reduce maintenance downtime.

3. SLURRY FORMING

When PAC is used in a slurry form the dry PAC exits the feeder and enters a wetting device. This device typically is a funnel installed under the discharge of the feeder. The inner surface of this funnel is covered with water to prevent PAC powder from sticking to the inside walls. Additional mixing is done either by discharging the wetted carbon to a mix tank, or by feeding the wetted carbon from the funnel to the suction of an eductor. The choice depends on the use of the slurry or the system designer's preference.

The following information details the four steps in the PAC slurry-forming process: premixing, slurry tank mixing, controlling dust, and pumping.

Premixing. Unlike most dry chemicals, which can be fed directly into a slurry tank and then mixed entirely by the tank's mechanical mixer, PAC requires some premixing to minimize dust and increase the contact time between the water and PAC.



To achieve premixing, install a funnel between the feeder outlet and the slurry tank inlet, with the funnel's larger end at the feeder outlet. The funnel should be equipped with a spray header that has several spray nozzles. The nozzles, installed around the periphery of the funnel's larger end, spray water into the funnel as the PAC flows from the feeder outlet. The turbulence starts to mix the water and PAC. As the water and PAC leave the funnel, they mix more thoroughly in the funnel discharge's vortex. This premixture, part dry and part wet, enters the slurry tank.

If your PAC feedrate is 100ft³/hr or more, you can achieve better premixing by adding an eductor between the funnel and slurry tank, as shown in Figure 1. After the eductor receives the premixture made in the funnel, the turbulence in the eductor provides more intense mixing. The eductor then delivers the dilute PAC slurry to the slurry tank, or directly to the process. In this case the eductor not only does further mixing, but also acts as a pump.

Slurry tank mixing. In the slurry tank, the slurry is blended with more water. Because PAC is insoluble in water, you can achieve a slurry maximum concentration of 10 to 15 percent solids. However, due to slurry tank and mechanical mixer size limitations, achieving a 5 percent solids concentration is a more practical goal. Typically, the slurry tank retention time is about 15 minutes so the mixer has time to combine the water and PAC.

For maximum mixing efficiency, offset the mixer from one tank axis and center it on the other axis. This will create a vortex that pulls the PAC from the slurry tank surface down to the bottom. Also use dual impellers to generate plenty of pumping action, minimize dead zones, and keep the PAC in suspension. A clamp mount mixer can also be used and mounted on the side of a tank with a 15-degree angle to vertical and an offset angle of 10-15 degrees.

Controlling dust. After the PAC leaves the funnel (and the eductor, if used) and enters the slurry tank, a significant amount of the powder remains unmixed and is airborne. Simply allowing this dust to remain inside the tank above the slurry won't ensure it mixing with the slurry. In fact, the dust is more likely to billow out of the tank at the feeder discharge before it becomes suspended in the slurry.

To control the dust, provide a positive airflow into the slurry tank by creating negative air pressure inside the tank. You can do this by installing a spray-in-pipe eductor above the tank inlet using a small draft-inducing eductor fan to draw the air from outside the tank into the tank. The eductor wet scrubs the dust from the air.

Pumping. A positive displacement or centrifugal pump discharges the slurry from the tank. Use a pump large enough to maintain a critical flow velocity (typically 5 to 7 ft/s) in the pump discharge line. The high velocity also

prevents PAC hardening, which can happen because of the powder's tendency to drop out of suspension after the slurry flow changes direction. After dropping out, the PAC collects in stagnation zones (also called impact zones), where it accumulates and hardens. You can't flush out such hardened deposits, but must remove them by mechanical means, or replacing the part with hard buildup.

To facilitate cleaning, also make sure the pump discharge line has several cleanouts for rodding or other mechanical cleaning. Equip the pump suction with a fresh-water flush connection so that you can flush PAC out of the system when it's shut down. A good choice for carbon slurry piping is stainless steel tubing or a plastic line. Use sweep turns and avoid using tubing or pipe fittings as much as possible.

To minimize wear, line the pump with elastomer. This is less costly than using a stainless steel pump.