Tech Brief

A NATIONAL DRINKING WATER CLEARINGHOUSE FACT SHEET

Diatomaceous Earth Filtration for Drinking Water

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Summary

Diatomaceous Earth (DE) filtration is a process that uses diatoms or diatomaceous earth—the skeletal remains of small, single-celled organisms—as the filter media. DE filtration relies upon a layer of diatomaceous earth placed on a filter element or septum and is frequently referred to as pre-coat filtration. DE filters are simple to operate and are effective in removing cysts, algae, and asbestos from water. DE has been employed in many food and beverage applications for more than 70 years and was used specifically to filter potable water during WWII. Since then, it has been used to produce high-quality, low-cost drinking water. DE filtration is currently one of the U.S. Environmental Protection Agency's (EPA) approved technologies for meeting the requirements of the Surface Water Treatment Rule (SWTR) and is most suitable for small communities that need to comply with the rule.

What is DE filtration?

DE contains fossil-like skeletons of microscopic water plants called diatoms, which are a type of algae. These diatoms range in size from less than 5 micrometers to more than 100 micrometers, and have a unique capability of extracting silica from water to produce their skeletal structure. When diatoms die, their skeletons form a diatomite deposit. In its natural state, diatomite is 85 percent inert silica. The soluble portion of diatomite is extremely low (less than 1 percent). The odorless, tasteless, and chemically inert characteristics make DE safe for filtering water or other liquids intended for human consumption.

Application and Historical Background

During WWII, the U.S. Army needed a new type of water filter suitable for rapid, mobile military operations. The U.S. Army Engineer Research and Development Laboratories (ERDL) developed a DE filter unit that was lightweight, easily transported, and able to produce pure drinking water. Later, DE filtration technology was applied to filtering swimming pool water and more gradually to producing drinking water.

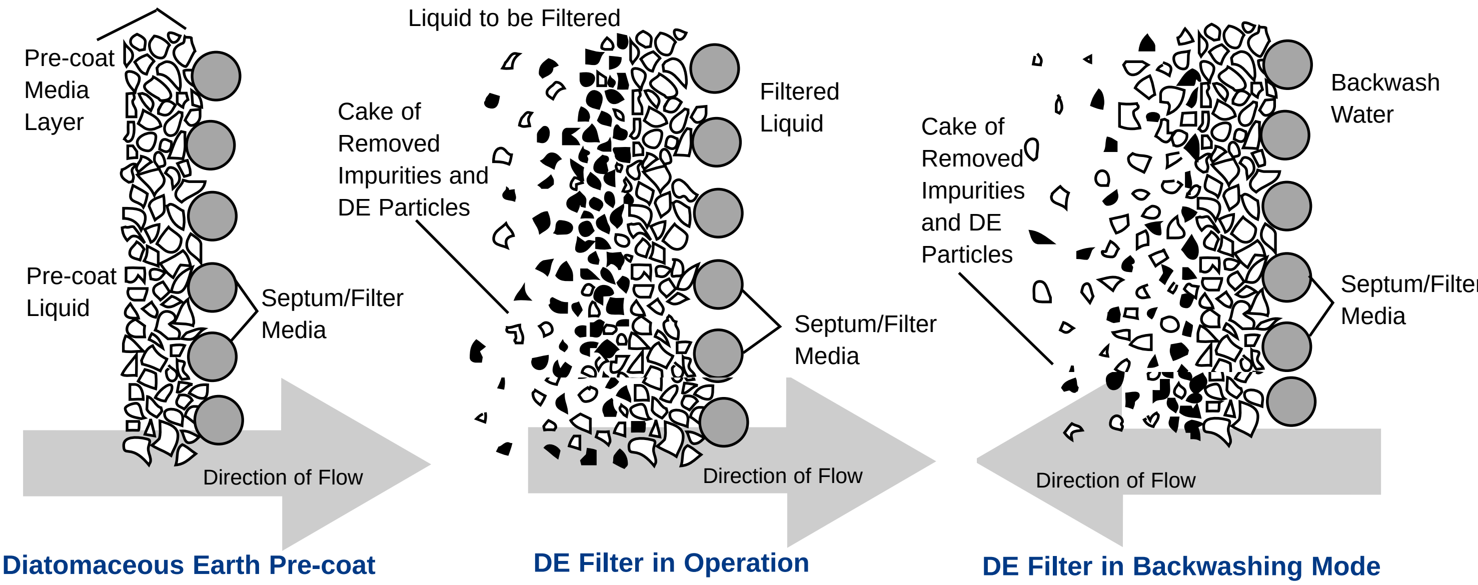
The earliest municipal DE filter installation was a 75,000 gallons per day (gpd) system in Campbell Hills, Illinois, that began operating in 1948. By 1977, municipalities had constructed more than 145 plants. Today, nearly 200 DE plants are successfully operating.

How does DE filtration work?

DE filtration strains particulate matter from water, and the process rarely uses coagulant chemicals. First, a cake of DE is placed on filter leaves. A thin protective layer of diatomaceous earth builds up, or accumulates, on a porous filter septum (a permeable cover over interior collection channels) or membrane. Recirculating DE slurry through the filter septum establishes this layer. The septum is most often plastic or metallic cloth mounted on a wire mesh-covered steel frame. The DE process is also called pre-coat filtration because the solids separation at the start of a run takes place on the built-up pre-coat layer of DE.

After the pre-coat forms on the filter leaves (usually 1/8 inch thick) raw water containing a low dose of DE, which is called body feed, is fed through the filter. Particulate solids in the

Figure 1 Diatomaceous Earth Filter



Source: Fulton, George P. 2000. *Diatomaceous Earth Filtration for Safe Drinking Water*

product flow are separated on the pre-coat surface. With such separation, the unwanted particulate matter actually becomes part of the filter media. During a filter run, removing particulate matter from raw water causes head loss to gradually build up in the filter. The accumulation of DE body feed on the filter reduces the rate of head loss. When maximum head loss is reached, the flow of water into the filter is stopped and the filter cake is cleaned.

High-pressure sprays, directed at the accumulated cake, detach the cake and provide dilution for draining the slurry suspension from the filter vessel. When cleaned, the filtration operation is repeated, beginning with the pre-coat cycle. *(See Figure 1.)* Operators typically discard the DE removed from the filter leaves.

Appropriate Feed Water Quality and Performance Capabilities

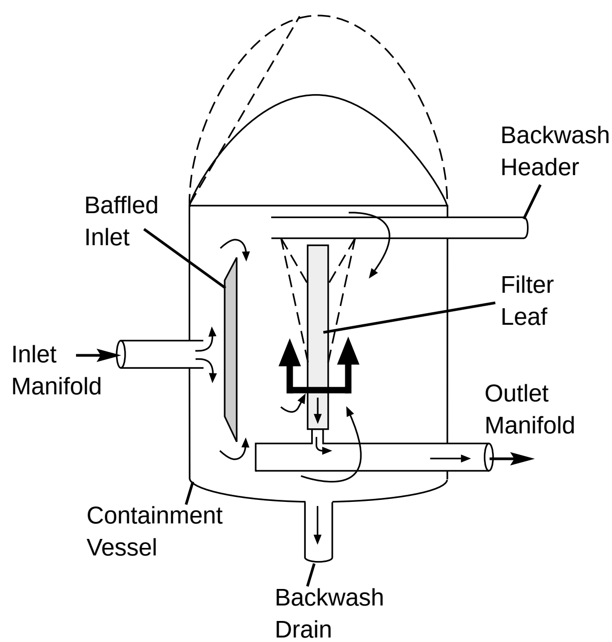
The use of DE filters is limited to treating source waters with an upper limit of turbidity at 10 NTU. Also, filtration rates range from 0.5 to 2 gallons per minute per square foot (gpm/ft^2). The particle size that DE filtration removes relies upon the size distribution of the DE particles used for the pre-coat and body feed. DE filters are very effective for removing *Giardia* and *Cryptosporidium* cysts. In some cases, studies have reported up to a 6-log reduction of these cysts under routine operating conditions. Because DE filtration usually does not involve coagulation, its potential for removing dissolved constituents, such as color, is low. Therefore, the utility or its engineer must determine raw water quality before considering DE filteration.

What are the monitoring and operating requirements?

Monitoring requirements for DE filtration are simpler than requirements for coagulation and filtration because operators rarely ever use coagulant chemicals for DE filtration. However, operators must continuously monitor raw and filtered water turbidity. Operators also must monitor filter head loss so that they can determine when to backwash the filter.

In general, DE filter plant operators need mechanical skills to operate the body feed pumps, pre-coat pumps, mixers, pipes, and

Figure 2 Elements of a Flat Leaf Filter



Source: Fulton, George P. 2000. *Diatomaceous Earth Filtration for Safe Drinking Water* valves. They also must be skilled in preparing the body feed and pre-coat slurries. Also, keeping DE filter leaves clean is of primary importance. A leaf filter that is not properly cleaned at the end of a filter run can accumulate dirt and slime on the filter cloth, which prevents a uniform pre-coat from forming when the filter is restored to service.

Elements of a DE filter

Figure 2 shows the common elements in the manufacture of any flat leaf filter used in treating drinking water. The principal elements of a DE filter include the following:

- containment vessel,
- baffled inlet,
- filter leaves mounted on an effluent manifold,
- a method of cleaning the filter leaves at the end of a run,
- a drain to receive the backwash water,
- open top or access mode, and
- DE slurry preparation tank and pump feed.

Figure 3-A Pressure Filter

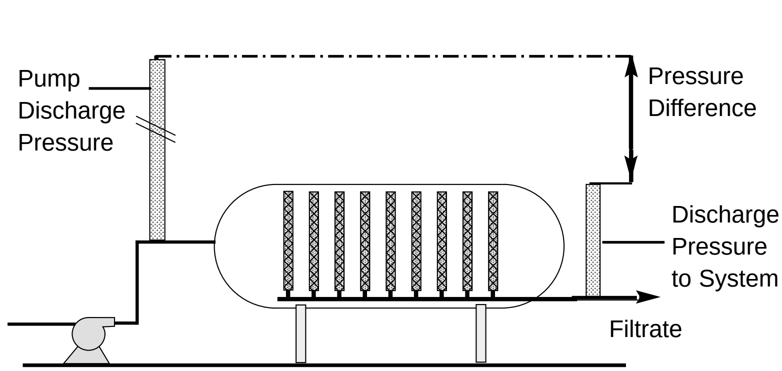
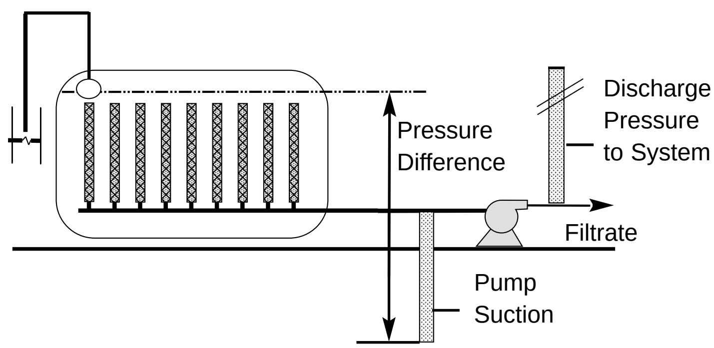


Figure 3-B Vaccuum Filter



Source: Fulton, George P. 2000. *Diatomaceous Earth Filtration for Safe Drinking Water*

Types of DE filtration

Two types of DE filters exist: (1) *pressure filters*, which have a pump or high-pressure water source on the influent side and (2) *vacuum filters*, which have a pump on the effluent side. Vacuum filters are open to the atmosphere. Pressure filters are enclosed within pressure vessels.

The two basic groupings of DE filter designs are essentially defined by the hydraulic mode of operation, and are shown in ***Figure 3-A and Figure 3-B.***

The principal advantages of pressure filters over the vacuum filters are related to the significantly higher differential head available.

Table 1 Pressure and Vacuum Filters

Pressure Filters	Vacuum Filters
• Operates at higher flowrates, resulting in smaller, more compact filter units.	• Lower capital fabrication cost.
• Longer filter runs, reducing the use of pre-coat material and backwash water because of less frequent cleaning cycles.	• Lower maintenance costs.
• Less likelihood that gas bubbles will disrupt the media.	• Tanks are open at the top, making access and observation easy.

Source: Mel J. Mirliss, Vipin Bhardwaj, and the National Drinking Water Clearinghouse

Is DE suitable for small systems?

DE filtration is well-suited to small systems, because it does not require chemical coagulation, so operators do not need to learn about this complex aspect of water treatment. In addition, installation costs for DE systems are less than those for other technologies, such as membranes. DE filtration is currently one of the EPA's approved technologies for meeting SWTR requirements.

An ideal, cost-effective DE filtration application is for well water supplies under the influence of surface waters, but that are otherwise acceptable in quality. Superior cyst removal capability makes the DE filter more advantageous than other alternatives. However, there is a potential difficulty in maintaining complete and uniform thickness of DE on the filter septum.

Where can I find more information?

- Fulton, George P., P.E. 2000. *Diatomaceous Earth Filtration for Safe Drinking Water*, American Society of Civil Engineers, Reston, VA.

- "Precoat Filtration." 1988. AWWA M30, *Manual of Water Supply Practices*. American Water Works Association, Denver, CO.

- *Technologies for Upgrading or Designing New Drinking Water Treatment Facilities*, EPA/625/4-89/023. (Available from the EPA) or contact the National Drinking Water Clearinghouse.

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Also, the NDWC's Registry of Equipment Suppliers of Treatment Technologies for Small Systems (RESULTS) is a public reference database that contains information about technologies used by small waters systems around the country. For further information about accessing or ordering RESULTS, call NDWC.

References:

Fulton, George P. 2000. *Diatomaceous Earth Filtration for Safe Drinking Water*, American Society of Civil Engineers, Reston, VA.

Safe Water from Every Tap, 1997. "Improving water service to small communities," National Research Council, National Academy Press, Washington, D.C.

Schuler, P.F., M.M. Gosh, and S.N. Boutros, 1988. "Comparing the removal of *Giardia* and *Cryptosporidium* using slow sand and diatomaceous earth filtration," pp. 789–805, *Proceedings of 1988 AWWA Conference*, Denver, CO.

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